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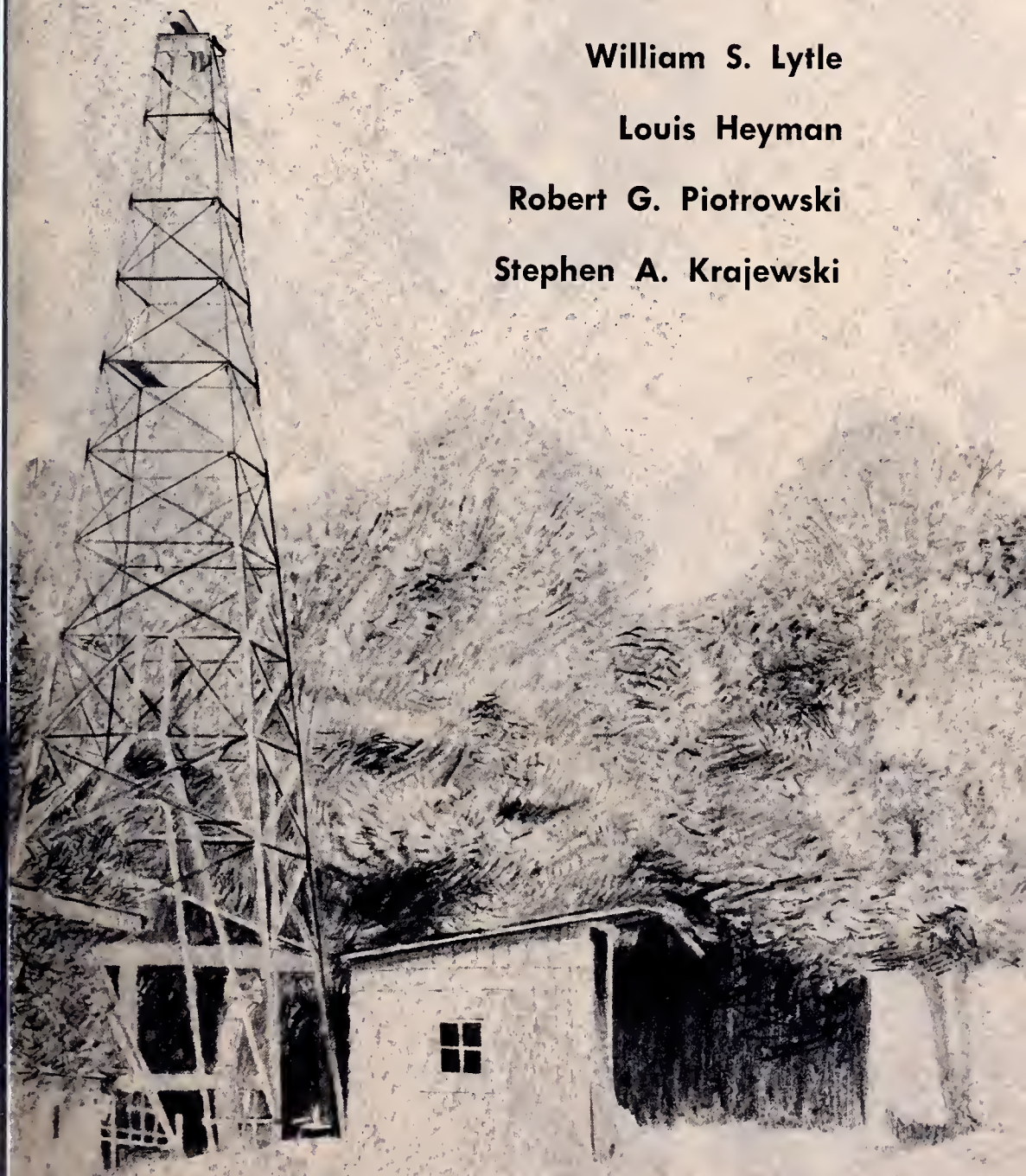
# **OIL AND GAS DEVELOPMENTS IN PENNSYLVANIA IN 1976**

**William S. Lytle**

**Louis Heyman**

**Robert G. Piotrowski**

**Stephen A. Krajewski**



*ON THE COVER:* Lee and Plumer's test well drilled in 1874 on the Divener farm, Donegal Township, Butler County, Pennsylvania, started flowing on February 28 at the rate of 1,000 barrels of oil per day. Data on the well shows the following daily production history: March 13—600 barrels, May 29—500 barrels, July 7—400 barrels, November 19—250 barrels, no record available for 1875, October 10, 1876—18 barrels, 1892—4 barrels of oil per day, 1905 drilled 12 feet deeper and production rose to 17 barrels, 1915—6 barrels per day, 1950—4 barrels per day and is still producing in 1977. The well is the most famous long-lived producer of all wells in the Butler District. Sketch by W. Thomas Lytle.

**COMMONWEALTH OF PENNSYLVANIA  
DEPARTMENT OF ENVIRONMENTAL RESOURCES**

**BUREAU OF  
TOPOGRAPHIC AND GEOLOGIC SURVEY  
Arthur A. Socolow, State Geologist**

**Progress Report 190**

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PENNSYLVANIA GEOLOGICAL SURVEY

FOURTH SERIES

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**1977**

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# CONTENTS

Page

Abstract	1
Introduction	2
Acknowledgements	2
Part I. Completion highlights for 1976	2
Shallow highlights	2
Pre-Speechley gas and oil development	3
Glade sandstone oil development	5
Other highlights	5
Part II. Oil and gas industry activity for 1976	5
Basis for statistics	5
Previous compilations	6
Indicated status of local industry	6
Drilling and completions	7
Production and reserves	7
Gas storage fields	15
Secondary and tertiary oil recovery projects	18
Oil and gas prices	18
Land sales	20
Geophysical activity	22
1976 Highlights	22
Industry related activities	23
Subsurface base maps	23
Part III. Oil and Gas Geology Division studies	29
Subsurface rock correlation diagram, Allegheny Plateau of Pennsylvania by Louis Heyman	29
References	32
Devonian shale research in Pennsylvania by Robert G. Piotrowski and Stephen A. Krajewski	33
Part IV. Summarized records of deep wells reported in 1976	43

## ILLUSTRATIONS

### FIGURES

Figure 1. Highlight wells reported in 1976	4
2. Shallow well activity, 1950-1976	15
3. Annual rate of deep sand exploration and development, 1930-1976	16
4. Oil and gas map of Pennsylvania showing exploratory wells reported in 1976	24

	<i>Page</i>
5. Annual production of crude oil in Pennsylvania . . . .	26
6. Crude oil prices, production and completions, Bradford District . . . . .	27
7. Production, consumption and reserves of natural gas in Pennsylvania . . . . .	28
8. Index of available subsurface base maps . . . . .	29
9. Subsurface rock correlation diagram Allegheny Plateau, Pennsylvania . . . . .	30
10. Area of Devonian black shales . . . . .	34
11. Gas production and show map for Devonian organic rich shales . . . . .	36
12. Index map for Pennsylvania stratigraphic cross sections . . . . .	38
13. Generalized stratigraphic column Middle and Upper Devonian of western Pennsylvania . . . . .	39
14. Schematic cross section C1-C3 . . . . .	40

## TABLES

Table 1. Shallow and deep highlight well statistics . . . . .	3
2. Well completions in Pennsylvania, 1976 . . . . .	8
3. Old wells drilled deeper in Pennsylvania, 1976 . . . . .	9
4. Drilling and completions reported, 1976 . . . . .	10
5. Exploratory and primary development reported, 1976 and 1975 . . . . .	11
6. Footage reported, 1976 and 1975 . . . . .	12
7. Reported discoveries in Pennsylvania, 1976 . . . . .	12
8. Selected exploratory failures reported in Pennsylvania, 1976 . . . . .	14
9. Production and reserves in Pennsylvania, 1976 . . . . .	17
10. Average daily oil production . . . . .	18
11. Deep gas production in Pennsylvania, 1976 . . . . .	19
12. Oil wells and crude oil produced in Pennsylvania by counties, 1974 and 1975 . . . . .	20
13. Crude oil prices per barrel, Pennsylvania, 1976 . . . . .	21
14. Summarized record of deep wells reported in 1976 . . . . .	44



# OIL AND GAS DEVELOPMENT IN PENNSYLVANIA IN 1976

by

William S. Lytle, Louis Heyman,

Robert G. Piotrowski and Stephen A. Krajewski

## ABSTRACT

Drilling for oil decreased 7 percent in 1976 from that of 1975 while gas well drilling decreased 11 percent. Seismic activity was down from 50 crew-weeks in 1975 to 40 crew-weeks in 1976 in 12 counties, with 50 percent Vibroseis and 50 percent conventional, costing operators about \$1,125,000. Oil production decreased while reserves increased and gas production increased and reserves decreased from 1975. The price of new and stripper crude oil per barrel in the Bradford District was \$13.07 in January and \$11.05 in February advancing to \$13.82 in September where it was steady for the rest of 1976. The price for intrastate natural gas at the wellhead ranged from 30 cents per Mcf under old contracts to as high as \$1.43 for new gas with a few contracts getting more. Under the Federal Power Commission the wellhead price of interstate gas ranged up to \$1.43 per Mcf.

The total number of highlight wells decreased from 119 in 1975 to 55 in 1976. The most active gas area was again in Indiana County with 243 new gas wells, down 131 from 1975. Venango, Warren and McKean Counties were the most active oil areas with 236, 186, and 109 wells drilled respectively.

Pennsylvania Grade crude oil production decreased 8 percent to 2,887,000 barrels, and Corning Grade crude decreased 6 percent to 63,000 barrels. Shallow gas production increased 6 percent to 76,632 MMcf, and deep gas increased 10 percent to 13,342 MMcf. Gas storage capacity decreased to 753,083 MMcf, and stored gas reserves decreased 14 percent to 512,861 MMcf.

Other well completions, including service, gas storage, and old well workovers, decreased 5 percent in 1976. The total of all wells reported in 1976 was down by 148, or 9 percent less than the 1975 total.

Of the 1,262 primary wells reported, 74 were exploratory and 1,188 were development. This is a 34 percent decrease in exploratory and an 8 percent decrease in development wells from 1975. Exploratory completions were 58 percent successful and development completions 99 percent successful.

Exploratory footage was down 34 percent and development footage was down 12 percent from that of 1975. The average depth of all wells was 2,239 feet, 124 feet less than in 1975.

The joint Maraflood operation between the Penn Grade Crude Oil Association and ERDA is underway in the tight Bradford sandstone in the Bradford field, McKean County.

## INTRODUCTION

Progress Report 178, *Representative Gamma-ray Logs from Shallow and Deep Wells, Western Pennsylvania*, should be referred to for stratigraphic information. Contained in this publication are three shallow gamma-ray logs (two from the oil belt and one from the gas fields) and one deep gamma-ray log on which shallow and deep producing intervals have been designated.

Part I of this report contains comments on wells in the commonwealth with good completions or of special note for other reasons. Part II contains the statistics and review of industry activities for the year. Part III contains a subsurface rock correlation diagram and explanation and a report on Devonian shale research in Pennsylvania. Part IV is the summarized record of the 1976 deep wells.

## ACKNOWLEDGEMENTS

Appreciation is hereby extended to the Oil and Gas Division of the Bureau of Land Protection and Reclamation, Pennsylvania Department of Environmental Resources, for the cooperation of that division in sharing the drillers' logs which are submitted to them by the operators under the oil and gas law.

We also acknowledge with appreciation the cooperation of the Pennsylvania Grade Crude Oil Association; the Pennsylvania Oil, Gas and Minerals Association; the Pennsylvania Game Commission; the American Gas Association; the American Petroleum Institute; Petroleum Information; the Pennsylvania Department of Environmental Resources' Bureau of Forestry, Division of Minerals.

Appreciation is extended to all operators and companies who released natural gas production statistics and other data.

## PART I. COMPLETION HIGHLIGHTS FOR 1976

### SHALLOW HIGHLIGHTS

The lower limits of initial production used in considering a shallow well (Upper Devonian or younger) as a highlight well were established at 50 Bopd or more and/or over 2 MMcfcpd.



There were 55 shallow highlight wells reported in 1976. A number of operators fail to report well initial production to the regulatory agency or else they estimate the initial production, which cannot be recorded as a correct figure. Therefore, there are probably several highlight wells that do not appear in the above figure. The shallow highlight wells compose 4.4 percent of the total exploratory and development wells reported (Table 5). Table 1 gives highlight well statistics.

Figure 1 shows the distribution of the highlight wells. The following is a brief description of those highlight occurrences about which information was released through the Oil and Gas Division of the Bureau of Land Protection and Reclamation.

### Pre-Speechley Gas and Oil Development

The Pre-Speechley (Upper Devonian Zone B) development gas play in the west-central part of the state decreased 13 percent from 1975 with 477 gas wells drilled in 1976 in a five-county area compared with 548 drilled in the same area in 1975. The number drilled increased in four counties and decreased in one county with 63 in Armstrong County in 1976 compared with 38 in 1975, in Clearfield 28 to 20, Indiana 243 to 374, in Jefferson 67 to 58, and in Westmoreland 76 to 58. There were 25 gas highlight

Table 1. *Shallow and Deep Highlight Well Statistics*

	<u>1976</u>			<u>1975</u>		
Fields and Pools with high-light wells	24			25		
Counties with highlight wells	8			8		
<i>Producing Zones</i>	<i>W e l l s</i>			<i>W e l l s</i>		
	<i>Gas</i>	<i>Oil</i>	<i>Total</i>	<i>Gas</i>	<i>Oil</i>	<i>Total</i>
Oriskany	0	0	0	0	0	0
Pre-Speechley in Zone B*	25	2	27	30	14	44
Speechley or Younger in Zone B*	0	24	24	0	66	66
Zone D*	1	3	4	0	9	9
Totals	26	29	55	30	89	119

\*Zone of Upper Devonian rocks established in Progress Report 178

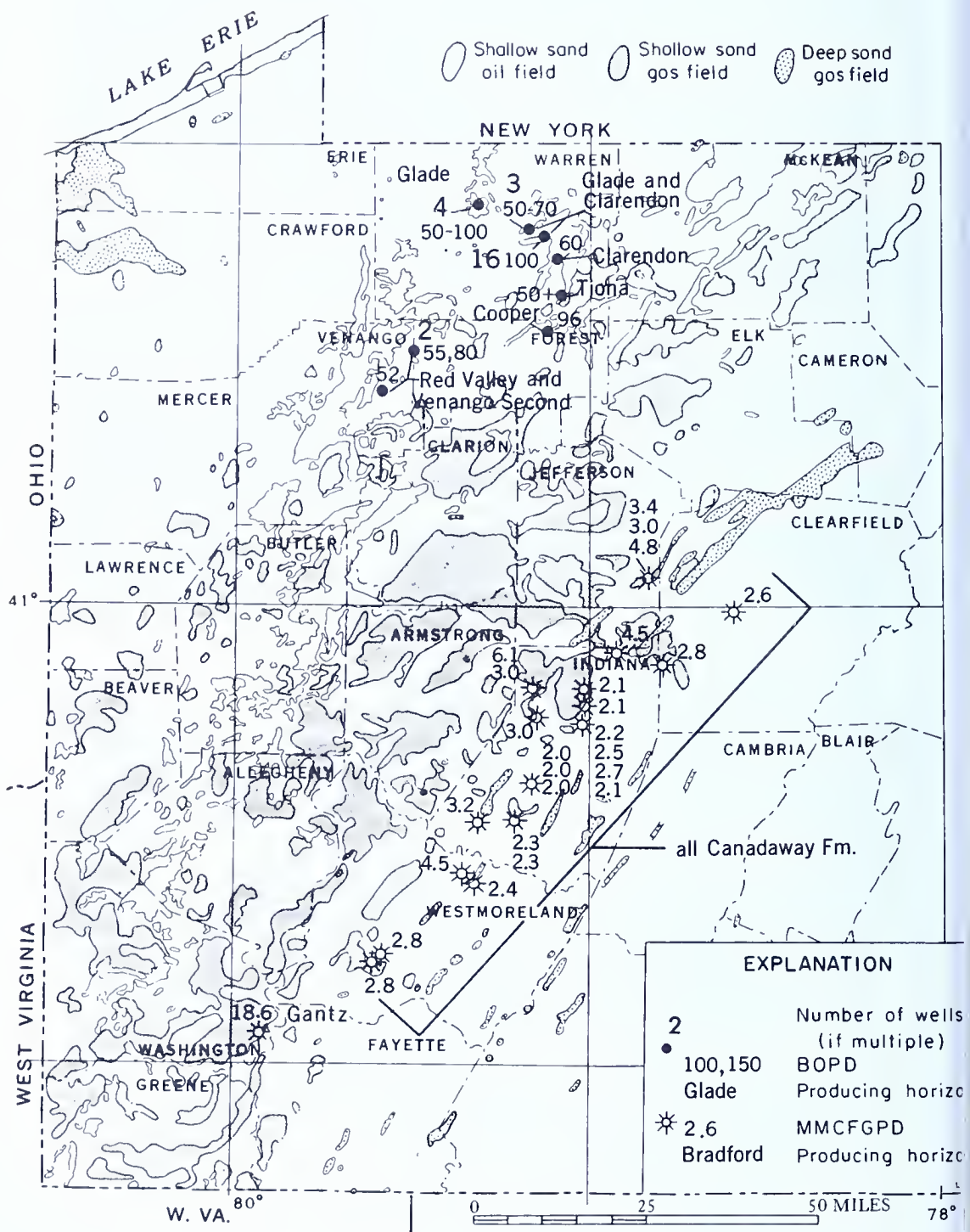


Figure 1. Highlight wells reported in 1976.

wells completed in this zone compared to 30 in 1975. Wells were completed with potentials in MMcfcpd as follows: Clearfield County in the Bell field 2.8, Grampian 2.6; Indiana County in the Crete field 2.0, Indiana 2 wells with 2.0, Lewisville 3.2, Marion Center 2.0, 2.1, 2.2, 2.3, 2.5, 2.7, 3.0, Plumville 6.1, Richmond-Big Run 4.5, Smathers 2 wells with 2.3, Smeltzer 3.0; Jefferson County in the Rathmel field 3.0, 3.4, 4.8; Westmoreland County in the Armbrust field 2 wells with 2.8, Blairsville 4.5, and in the New Alexandria field 2.4.

Two highlight oil wells were reported producing from this zone as follows, with potentials in Bopd: Forest County—Cooper field 96; Warren County—Duck Eddy pool at an estimated 200.

### Glade Sandstone Oil Development

During the year there were 24 crude oil highlight wells drilled in Warren County with production from the Glade and associated sands. The fields in which the wells are located are shown below, with their initial productions in Bopd: Clarendon 60; Morrison Run 16 with 100; Sill Run with 1-50, 1-60, 1-70; and Youngsville 1 with 50 and 3 with 100.

### Other Highlights

Three oil wells were productive from Zone D: Asbury Chapel field 1 with 55 Bopd; Muskrat Run field with 52; and Pleasantville field with an 80 bbl. well. Only one Zone D gas highlight well was reported. The well discovered the Granville pool with an initial production of 18,600 Mcfcgd. There were no deep (Middle Devonian or older) highlight wells during 1976. A deep well limit of 10 MMcfcpd or more must be met before the well is classified as a highlight well.

## **PART II. OIL AND GAS INDUSTRY ACTIVITY FOR 1976**

### **BASIS FOR STATISTICS**

Local industry statistics herein reported are consistent with figures submitted to national industry organizations. Consequently, drilling and completion data are entirely based on drillers' records and location plats forwarded to the Pennsylvania Geological Survey by the Oil and Gas Division of the Bureau of Land Protection and Reclamation of the Department of Environmental Resources, the administrative and regulatory agency for the oil and gas laws. Only those wells for which records and plats have been received within the year are reported. This includes wells drilled in prior years for which records were submitted and received in

1976. It does not include 1976 wells completed for which records had not been submitted within the year.

Oil production and reserve data were obtained from the American Petroleum Institute and gas production and reserve data were obtained from the American Gas Association.

## PREVIOUS COMPILATIONS

The summarized records of deep wells (those which reach rocks of Middle Devonian age or older) are shown in Table 14 and the locations of all exploratory wells are on Figure 4 (centerfold). For those deep wells drilled prior to 1950, the summarized records and other information on the commonwealth's oil and gas activities are to be found in Mineral Resource Report 31 (Pennsylvania Geological Survey). Similar information for the 1950 to 1954 period was published in Mineral Resource Report 39, and for the 1955 to 1959 period in Mineral Resource Report 45. For years 1960 through 1975, this information was published annually in Progress Reports 158, 160, 165, 166, 168, 172, 173, 175, 177, 181, 183, 184, 186, 187, 188 and 189 of the Pennsylvania Geological Survey. Oil and gas developments in the shallow sands (Upper Devonian or younger) are described in Mineral Resource Report 45 and in Progress Reports 135, 139, 143, 144, 147, 150, 151, 154, 155, 157, 158, 160, 165, 166, 168, 172, 173, 175, 177, 181, 183, 184, 186, 187, 188 and 189.

A list of deep-well samples on file with the Survey was published in the Survey's *Catalogue of Deep Well Samples and Geophysical Logs to January 1, 1959* (W. R. Wagner, Inf. Circ. 16). Supplemental lists were published in Progress Reports 157, 158, 160, 165, 166, 168 and 173. These and other deep and shallow well samples, geophysical logs, and other well data are also on file with the Survey.

## INDICATED STATUS OF LOCAL INDUSTRY

Oil well completions 640 in 1976, decreased 7 percent from the 686 completions in 1975. Pennsylvania Grade crude oil production decreased from 3,132 M bbls. in 1975 to 2,887 M bbls. in 1976; an 8% decrease, while oil reserves, due to revisions, increased 5% to 49,975 M bbls. from 47,377 M bbls. in 1975. Crude oil prices decreased during the first part of the year but hit a new high of \$13.82 per barrel during the final four months. Corning Grade crude oil production decreased 6% to 63,000 bbls.

Gas well completions decreased from 640 in 1975 to 565 in 1976. Completion of wells classified as oil and gas wells increased from 5 in 1975 to 11 in 1976. Total reserves of gas decreased 2% while production increased 6%. The amount of gas in storage decreased 14%.



## Drilling and Completions

The breakdown of completions by county is shown in Table 2 and the old wells drilled deeper in Table 3.

Table 4 shows that drilling for oil and gas decreased 9% in 1976 from that in 1975 when there was a 12% increase over that of the previous year. During the year exploratory and development drilling decreased 34 and 8 percent respectively from 1975, as shown in Table 5.

The total footage in 1976 was down 17% with respect to the amount drilled in 1975 (Table 6).

The 1976 reported discoveries are listed in Table 7 and selected reported exploratory failures are listed in Table 8. Locations of all the exploratory tests are shown in Figure 4. Figure 2 is a graph of the annual rate of shallow activity in the commonwealth from 1950 to 1976, while Figure 3 shows the annual rate of deep exploration and development from 1930 to 1976.

At the end of 1976 a total of 3,386 deep wells had been drilled since the beginning of exploration in the deeper horizons. Of the 3,386 deep wells, 1,814 were gas wells, 147 oil and gas wells, 1,196 dry holes, 223 gas storage wells, 4 for waste disposal, and 2 for testing drilling equipment.

In addition to the 46 dry holes drilled in 1976 and plugged and abandoned, there were 1,375 old oil wells and 72 old gas wells that were plugged and abandoned.

## Production and Reserves

As shown in Table 9 during 1976, oil production decreased and reserves, due to revisions, increased while gas production increased and reserves decreased from 1975.

The 2,887,000 barrels of Pennsylvania Grade crude had a value of about \$35,096,338 when it is all classified as new or stripper oil. The 63,000 barrels of Corning Grade crude oil was produced from the Medina sandstone (Lower Silurian), mostly in Crawford County. This oil had a value of approximately \$764,977. Development drilling for crude oil was down 7 percent for 1976 from 1975. Figure 6 shows the crude oil prices, production and completions for the Bradford District, which includes all of the Bradford Field, for the years 1930 to 1976.

Figure 5 shows the annual production of crude oil in Pennsylvania from 1859 to 1976 and in the entire Bradford field from 1871 to 1976.

At the end of 1976 there were approximately 17,391 producing gas wells in the commonwealth. The 89,974,000 Mcf of shallow and deep gas shown in Table 9 can be divided into 76,632,000 Mcf of shallow gas and 13,342,000 Mcf of deep gas produced in Pennsylvania during 1976. Figure 7 shows the following for the years 1946 to the present: 1) the yearly



Table 2. Completions in Pennsylvania, 1976\*

T O T A L			G A S			O I L			O I L & G A S			O R Y		
County	No. of Wells	Aver. Total Depth (feet)	No. of Wells	Aver. Init. Open-Flow (Mcfgpd)	Aver. Total Depth (feet)	No. of Wells	Aver. Init. Production (Bopd)	Aver. Total Depth (feet)	No. of Wells	Aver. Init. Production (Bopd)	Aver. Total Depth (feet)	No. of Wells	Aver. Total Depth (feet)	
Allegheny.....	1	3,631	1	207	3,631	0	0	0	0	0	0	0	0	
Armstrong.....	65	3,532	63	492	3,506	1	3	1,122	0	0	0	1	7,533	
Beaver.....	1	6,666	1	127	6,666	0	0	0	0	0	0	0	0	
Butler.....	2	1,601	0	0	0	1	2	1,662	0	0	0	1	1,540	
Cambria.....	1	4,011	0	0	0	0	0	0	0	0	0	1	4,011	
Clarion.....	14	2,671	6	100	2,557	5	4	1,392	0	0	0	3	5,033	
Clearfield.....	31	4,098	28	741	4,182	0	0	0	0	0	0	3	3,312	
Clinton.....	3	1,529	2	50	998	0	0	0	0	0	0	1	2,623	
Crawford.....	24	3,749	10	1,138	4,749	5	9	705	6	100	4,231	3	4,526	
Elk.....	6	2,437	2	48	2,382	3	4	2,283	0	0	0	1	3,011	
Erie.....	16	3,198	14	977	3,198	0	0	0	0	0	0	2	3,198	
Fayette.....	2	3,545	0	0	0	0	0	0	0	0	0	2	3,545	
Forest.....	105	1,410	9	121	2,454	89	18	1,255	0	0	0	7	2,027	
Indiana.....	245	3,662	243	913	3,662	0	0	0	0	0	0	2	3,643	
Jefferson.....	68	3,496	67	552	3,493	0	0	0	0	0	0	1	3,682	
Lawrence.....	1	906	1	10	906	0	0	0	0	0	0	0	0	
Lycoming.....	1	6,325	1	1,100	6,325	0	0	0	0	0	0	0	0	
McKean.....	116	1,857	3	35	2,256	109	4	1,733	2	Not Listed	1,940	2	7,914	
Mercer.....	2	4,823	1	231	9,246	0	0	0	0	0	0	1	400	
Potter.....	4	1,363	0	0	0	4	6	1,363	0	0	0	0	0	
Somerset.....	1	3,501	0	0	0	0	0	0	0	0	0	1	3,501	
Tioga.....	1	4,660	0	0	0	0	0	0	0	0	0	1	4,660	
Venango.....	237	775	0	0	0	236	14	776	0	0	0	1	650	
Warren.....	193	1,072	1	200	2,014	186	32	1,056	3	323	1,680	3	1,138	
Washington.....	8	3,738	7	2,807	3,879	0	0	0	0	0	0	1	2,756	
Westmoreland...	81	3,720	76	853	3,742	0	0	0	0	0	0	5	3,383	
TOTAL.....	1,229	2,302	536	791	3,630	639	18	1,104	11	166	3,118	43	3,351	

\*Does not include service wells, miscellaneous wells, gas storage wells, stratigraphic/core tests or old wells drilled deeper.

\*\*Initial productions for majority of wells not given.

Table 3. Old Wells Drilled Deeper in Pennsylvania, 1976

T O T A L			G A S			O I L			D R Y		
County	No. of Wells	Aver. Amt. Deepened (feet)	No. of Wells	Aver. Init. Open-Flow (Mcftgpd)	Aver. Amt. Deepened (feet)	No. of Wells	Aver. Init. Production (Bopd)	Aver. Amt. Deepened (feet)	No. of Wells	Aver. Amt. Deepened (feet)	
Armstrong.....	5	934	4	275	1,127	0	0	0	1	163	
Butler.....	1	1,081	0	0	0	0	0	0	1	1,081	
Clarion.....	1	100	1	5	100	0	0	0	0	0	
Elk.....	2	229	1	14	375	0	0	0	1	83	
Indiana.....	12	1,023	12	503	1,023	0	0	0	0	0	
Jefferson.....	7	644	7	382	644	0	0	0	0	0	
Venango.....	1	394	0	0	0	1	1	394	0	0	
Washington.....	1	650	1	60	650	0	0	0	0	0	
Westmoreland.....	3	426	3	806	426	0	0	0	0	0	
TOTAL.....	33	770	29	424	817	1	1	394	3	442	

Table 4. Drilling and Completions Reported, 1976

Classification		1 9 7 6					1 9 7 5					% Change	
		Gas	Oil	O & G	Dry	Total	Gas	Oil	O & G	Dry	Total		
SHALLOW	New	Gas Oil & Gas Dry Total	499	639	5	31		578	686	5	44		- 14 - 7 0 - 30 - 11
	Deepened	Gas Oil Dry Total	29	1		3		31	0		6		- 6 + 100 - 50 - 11
	Sub Total	Gas Oil Oil & Gas Dry Total	528	640	5	34		609	686		50		- 13 7 0 - 32 - 11
DEEP	Deepened & New	Gas Oil & Gas Dry Total	37		6	12		28		0	21		+ 32 + 600 - 42 + 12
PRIMARY	Sub Total	Gas Oil Oil & Gas Dry Total	565	640	11	46		637	686		71		- 11 - 7 + 120 - 35 - 10
Misc.	Service (Gas & Water Injection Wells) Gas Storage Old Well Workovers												- 49 - 63 + 32
TOTAL ALL WELLS													- 9

Table 5. Exploratory and Primary Development Reported, 1976\*

Type Well	Gas	1 9 7 6 O & G			Total	1 9 7 5 O & G			Total	% Change
		Gas	Oil	Dry		Gas	Oil	Dry		
EXPLORATORY	Gas	33	9			46	9			- 28
	Oil & Gas Dry			31				55		0
	Total (% Successful)				74 (58%)				112 (51%)	- 50
										- 44
										- 34
DEVELOPMENT	Gas	532	631			591	677			- 10
	Oil & Gas Dry			15				16		- 7
	Total (% Successful)				1188 (99%)				1287 (99%)	+ 233
										- 6
										- 8
TOTALS	Gas	565	640			637	686			- 11
	Oil & Gas Dry			46				71		- 7
	Grand Total (% Successful)				1262 (96%)				1399 (95%)	+ 120
										- 35
										- 10

\*Above figures include old wells drilled deeper

Table 6. Footage Reported, 1976 and 1975\*

1976 No. of Wells	Class	Footage		% Change	Average Feet Per Well	
		1976	1975		1976	1975
74	Exploratory	289,118	438,840	- 34	3,907	3,918
1,188	Development	2,565,937	2,914,501	- 12	2,160	2,265
49	Service & Strat.	75,312	171,180	- 56	1,537	1,765
1,311	SUB TOTAL	2,930,367	3,524,521	- 17	2,235	2,356
3	Gas Storage	11,254	29,966	- 62	3,751	3,746
1,314	TOTAL	2,941,621	3,554,487	- 17	2,239	2,363

\*Above figures include old wells drilled deeper

Table 7. Reported Discoveries in Pennsylvania, 1976

Map No.	County	Operator Well No. & Lease	Compl. Date	Total Depth (ft.)	Name of Formation at T.D.	Prod. Depth (ft.)	Prod. Formation or Zone	Initial Daily Prod.	Field or Pool Name	Explor. Class	Remarks
49	Beaver	Quaker State Oil Ref. 1 Metropolitan Ind.	2/ 6/75	6,666	Queenston	3,930	U. Devonian Shale	127 Mcf	Darlington Field	NFD	First Upper Devonian shale gas well in Western Pennsylvania.
45	Clarion	UGI Development Co. 1 Mealy	8/25/76	2,310	Canadaway Group	1,099	Knox Third	5 Bbl	Wolfs Corners	NPD	Discovery in Red Bush Field in a predominately gas producing area.
70	Clarion	Clarion State Oil Co.	1/15/76	7,701	U. Devonian	2,950	Canadaway	225 Mcf	Twick Dun	SPN	Dev extension to dean Anderson Creek



72	Consol. Gas Supply 1 Guy Ross	9/15/76	6,677	Salina	6,395	Onondaga Chert	215 Mcf MoShannon Pool	NP0	New pool discovered in the Punxsutawney-Oriftwood field.
23	Consol. Gas Supply 1 Blake L. Tubbs	6/ 9/76	4,798	Canadaway Group	3,072	Canadaway Group	605 Mcf Lumber City Field	NP0	Shallow gas discovery in a rank wildcat area.
51	N-Ren Corporation 1 Kibert Developers	10/31/73	4,990	Queenston	4,953	Medina	1,229 Mcf Greenwood Field	NP0	Medina field discovery in northwestern Pennsylvania.
57	Van Raalte Oil Co. 1 John F. Tobin	1/31/76	4,072	Queenston	3,943	Medina	2,200 Mcf Cambridge Springs Field	NP0	Another Medina discovery in the Medina fairway of northwestern Pennsylvania.
40	Forest John A. Vertullo 9 J. V. Lot 5213	11/20/75	1,630	Canadaway	1,500	Canadaway Group	15 Bbl Kellettville 20 Mcf Pool	NP0	Discovery of oil production in Whig Hill field.
43	Endeavor Ventures 4 Lot 5200	10/ 9/74	1,335	Queen	1,283	Queen	700 Mcf Lot 5200 Pool	NP0	Discovery of Queen sand production two miles south of old Queen sand gas field.
67	Lycoming John H. Ware 1 Mary L. Hess	6/24/76	6,325	Holderberg	6,295	Oriskany	1,100 Mcf Salladasburg Field	NP0	Discovery on Tombs Run anticline, one of the easternmost Oriskany fields.
33	McKean Thomas J. George 11 Chappel Fork	1/20/76	1,863	Third Bradford	1,525	Second Bradford	8 Bbl Lafayette 52 Mcf Pool	NP0	Discovery just south of the old Klondike pool.
31	Apoalachian Petroleum K-APC-1 Wt. 2187	3/24/76	1,899	Kane	1,376	Second Bradford	40 Bbl Brooder Hollow Pool	NP0	New pool discovery just east of the Bradford field.
32	NE Natural Gas Co. 1 Kendall E. Br. 140	9/20/76	2,198	Third Bradford	1,768	Tiona	6 Bbl Red Bridge Pool	NP0	Discovery in Morrison field.
50	Mercer Peoples Natural Gas 1 James Fleck	8/27/75	9,246	Precambrian	5,040	Medina	231 Mcf Fleck Pool	DP0	Basement test with production from Medina & possibly from U Devonian shale.
36	Warren Viking Resources 1 Nat. Fuel Lot 363	8/24/76	1,740	Tiona	1,740	Tiona	50 Bbl Duck Eddy 1,000 Mcf Pool	NP0	Discovery between two old producing areas in northwestern Pennsylvania.
35	Wallace Oil and Gas 2 Turner Lease	5/14/76	1,647	Glade	1,625	Glade	27 Bbl Lukins School 35 Mcf Field	NP0	Extension of Glade sand production to southwest of Youngsville field.
3	Washington Peoples Natural Gas 1 Hallie Taylor	10/ 3/76	2,340	Gantz	2,330	Gantz	18,600 Mcf Granville Pool	NP0	New pool discovery west of the main Belleverson field.

Table 8. Selected Exploratory Failures Reported in Pennsylvania, 1976

Map No.	County	Operator Well No. & Lease	Compl. Date M-Day-Y	Total Depth (Ft.)	Name of Formation at T.D.	Explor. Class or Field	Remarks
61	Clarion	Peoples Natural Gas Co. 1 John J. Howard	3/ 4/76	7,460	Queenston	OPT	Silurian test on seismic high in Knox shallow oil field.
60		Peoples Natural Gas Co. 1 Leland D. Shirey	8/28/76	5,405	Helderberg	OPT	Oriskany test on seismic high in Beall shallow gas field.
30	Clinton	N. Y. - Petro - Min - Corp. 1 Winner	11/ 2/73	2,623	Canadaway	NFW	Three mile western stepout from Keating field to test Speechley and associated rocks.
1	Fayette	Cyclops Corporation 1 Alex Kennedy	11/20/75	4,380	Canadaway	NFW	Test along eastern edge of gas producing belt in western Pennsylvania.
63	Forest	John Vertullo 65-DJV, Lot 5212	12/ 1/75	6,375	Queenston	DPT	Medina (Lower Silurian) test productive in Queen (Upper Devonian).
44		UGI Development Company 1 C and J. Smith	7/30/76	2,190	Canadaway	NFW	Canadaway test between Speechley and Lory fields.
41		John A. Vertullo 1 JV Lot 5219	12/ 1/75	1,707	Canadaway	NPW	Test of Queen sand north of Queen gas storage field.
62		Quaker State Oil Ref. Corp. 1 H. Levorson	3/12/75	6,484	Queenston	NFW	Silurian test east of Whig Hill field.
73	Jefferson	Consolidated Gas Sup. Corp. WN-1518 R & P Coal Company	8/ 4/76	7,264	Helderberg	OPT	Onondaga chert test on upside large fault bounding Sabinsville anticline, gas productive U. Devonian.
74		Consolidated Gas Sup. Corp. 1 Ollie Morris	11/25/75	7,127	Helderberg	OPT	Onondaga chert test on upside of large fault, aborted due to pipe failure, gas in Upper Devonian.
64	McKean	Fairman Drilling Co. 1 Erie Lackawanna R.R.	3/ 9/76	5,645	Helderberg	OPT	Onondaga reef test, no reef development, Oriskany absent.
65		Minard Run Oil Company 1 Say	5/ 5/76	10,182	Little Falls	EXT	Dry extension test of Upper Cambrian, Minard Run pool.
48	Mercer	Clyde Varner 1 Clyde Varner	12/ 1/75	400	Red Valley	NPT	Non commercial gas test of Upper Venango Group (Upper Devonian).
66	Tioga	Consolidated Gas Sup. Corp. 1 Carroll Neal	9/ 9/76	4,660	Oriskany	NFW	Seismic prospect possible dome, tested Oriskany (Lower Devonian).
34	Warren	W. F. Clinger 1 Weaver A. Warrant	3/27/76	1,150	Glade	NFW	Glade Sandstone test in area 5 miles south of main Glade oil production.
		Peoples Natural Gas Co.	11/17/76	3,460	Canadaway	NFW	Stratigraphic test of Upper Devonian on northwest

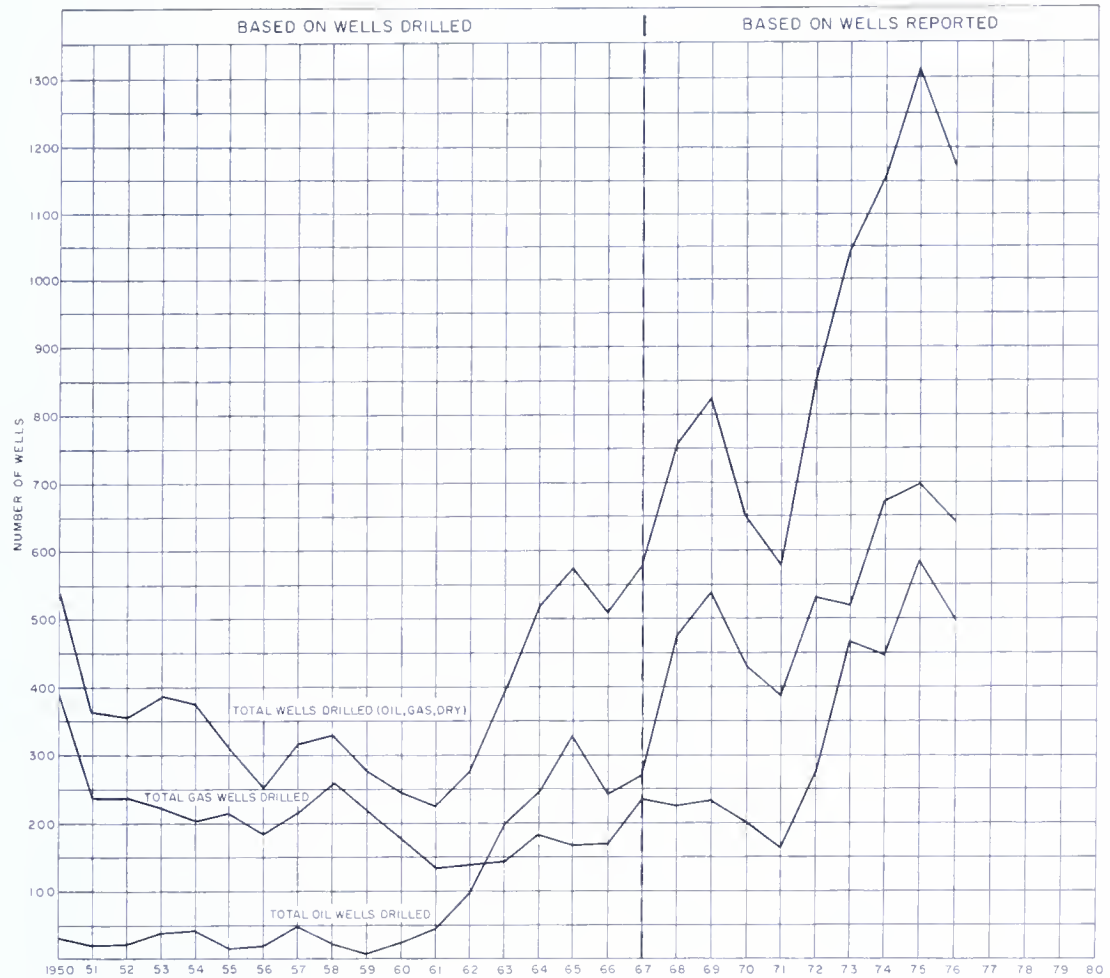


Figure 2. Shallow well activity, 1950-1976.

production of natural gas; 2) the yearly consumption of natural gas; 3) total natural gas reserves; and 4) the amount of natural gas in storage. The consumption of natural gas in the state continues to decline from its high in 1972 of 829,031,000 Mcf to 653,810,000 Mcf in 1975. Deep gas production by field and pool is shown in Table 11.

### Gas Storage Fields

Three wells were drilled for gas storage during the year, 1 of which was a deep well and 2 were shallow. Several gas storage wells were worked over during the year. Storage well drilling activity was down 63 percent from 1975. Figure 8 of Progress Report 186 shows the distribution and lists the names of the current gas storage fields in Pennsylvania. These fields are also shown on our large gas storage map at a scale of 1:500,000 and on the gas pipeline map of the same scale. Both maps are available at the Survey's Pittsburgh office at cost of reproduction.

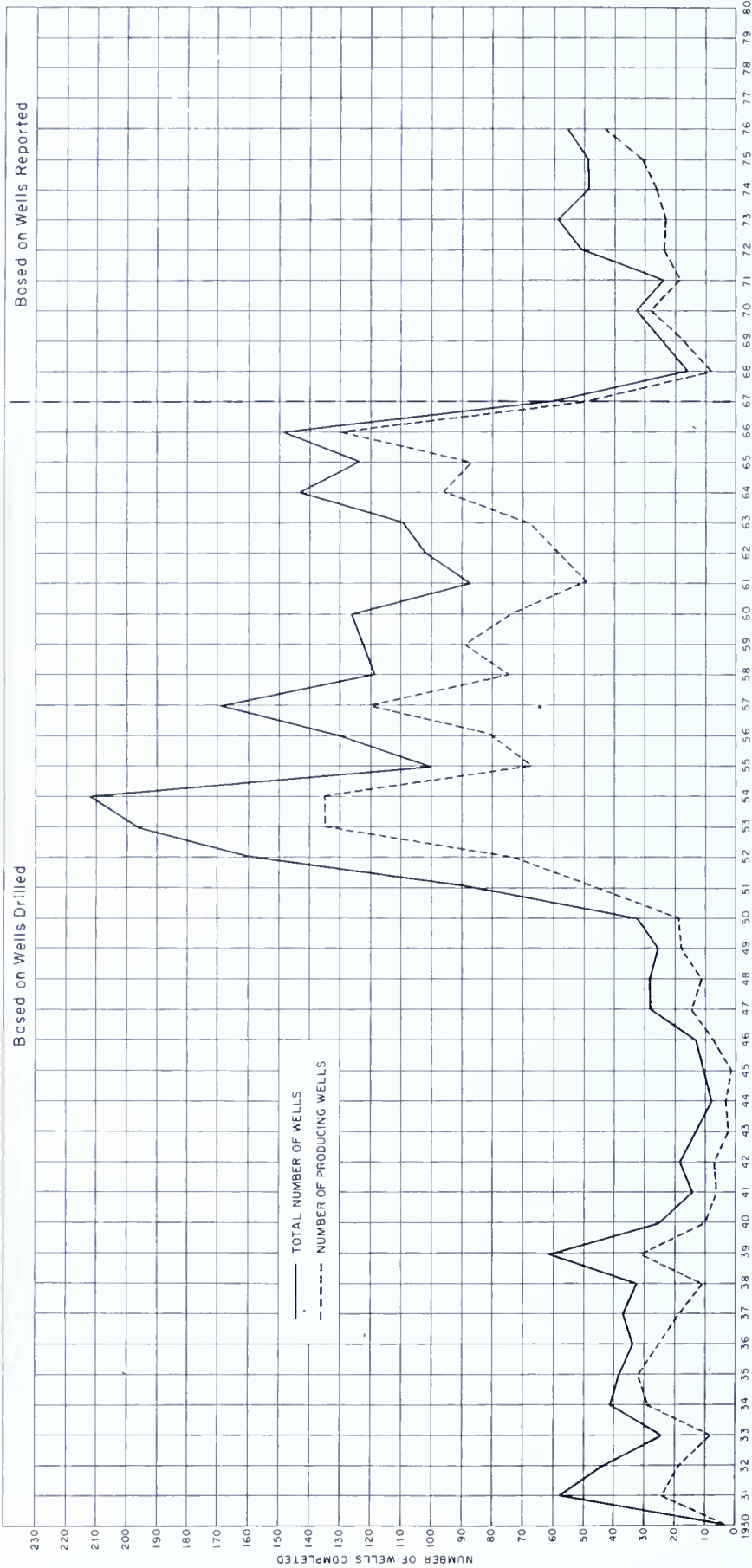


Figure 3. Annual rate of deep sand exploration and development, 1930-1976.

Table 9. Production and Reserves in Pennsylvania, 1976

	Production			Reserves			
	1976	1975	% Change	Cumulative to 12/31/76	1976	1975	% Change
Penna. Grade	2,887	3,132	- 8	1,288,944	49,975	47,377	+ 5
Corning Grade	63	67	- 6	620	588	651	-10
TOTAL OIL	2,950	3,199	- 8	1,289,564	50,563	48,028	+ 5
Natural Gas Liquids (1,000 bbls.)	69	65	+ 6	---	446	515	-13
Shallow	76,632	72,620	+ 6	---	---	---	---
Deep	13,342	12,152	+10	---	---	---	---
TOTAL GAS	89,974	84,772	+ 6	9,013,560	1,651,898*	1,682,460*	- 2
Stored Recoverable Gas					512,861	596,324	-14

\*Stored Recoverable Gas Included



Table 10. Average Daily Oil Production

<i>District</i>	<i>1976</i>	<i>1975</i>	<i>% Change</i>
Bradford District.....	3,570	4,263	-16
Middle and Southwestern District.....	4,340	4,317	+ 1
Medina (Corning).....	175	184	- 4
TOTAL.....	8,085	8,764	- 8

Storage capacity decreased during the year to 753,083,000 Mcf compared to 755,497,000 Mcf in 1975. The total stored recoverable gas on December 31, 1976 was 512,861,000 Mcf or 14 percent less than the amount in storage on December 31, 1975. Gas in storage consisted of 28,632,000 Mcf of gas native to the storage fields and 519,565,000 Mcf from many sources pumped into the storage fields.

### Secondary and Tertiary Recovery Projects

There were 49 water or gas injection wells completed during the year, down 49 percent from the number completed in 1975. In McKean County, 109 oil wells were completed, most of them in secondary recovery projects. The waterflooding in McKean County produced about 44 percent of Pennsylvania's yearly crude oil production. The number of producing oil wells and the crude oil production by county for the years 1974 and 1975 are shown in Table 12.

The McKean County Bradford field Maraflood project continues into its eighth year of operation on an economical basis. The joint Maraflood project in the tight Bradford sandstone in the Bradford field sponsored by the Penn Grade Crude Oil Association and ERDA is continuing.

### Oil and Gas Prices

Crude oil prices for the year are shown in Table 13. A wide variety of prices were paid at the wellhead for gas during the year in the commonwealth. The price ranged from 30 cents per Mcf under old contracts to as high as \$1.43 for new gas delivered as intrastate gas. A few contracts were higher than \$1.43 due to specific production terms. The wellhead price of interstate gas ranged up to \$1.43 per Mcf for new gas under the Federal Power Commission opinion (effective January 1, 1975) #770 amended by #770-A.

Table 11. Deep-Gas Production in Pennsylvania, 1976

19

County	Field	Pool	Discovery Date	Cumulative Production at End of 1975 (In Mcf)	Production 1976 (In Mcf)	Cumulative Production at End of 1976 (In Mcf)	Status of Field or Pool at End of 1976
Armstrong.....	Goehenville* Roaring Run*	Snyderville Roaring Run Oriskany	10/23/70 12/14/70	201,495 3,959,850	12,785 1,054,073	214,280 5,013,923	Producing Producing
Cambria.....	Patton	Burley Pindleton	1/15/69 6/30/69	164,040 3,795,891	60,796 360,754	224,836 4,156,645	Producing Producing
Cameron .....	Canoe Run East Emporium		8/24/73 11/18/71	2,113,000	441,555	2,554,555	Production not available Producing
Cameron & Elk.....	Whippoorwill		7/10/61	15,294,000	155,070	15,449,070	Producing
Cameron, Elk, Jefferson, Clear- field and Indiana....	Punxsutawney* Driftwood	TOTAL Benezette Oriftwood Boone Mt. DuBois Sabula Helvetia Reed- Olemer Rockton Sykesville Hicks Run	9/15/51 1/ 5/53 9/15/51 9/18/58 1/ 6/60 8/26/63 5/11/60 5/ 9/55 12/ 1/53 2/25/55 11/10/60 6/ 7/56	483,530,000 247,325,000 103,900,000 899,000 127,190,000 4,216,000	2,143,928 779,584 591,326 37,278 701,396 34,344	485,673,928 248,104,584 104,491,326 936,278 127,891,396 4,250,344	Producing Producing Producing Producing Producing Producing
Clearfield.....	Beech Run Boone Mt. West Decatur	Anderson Creek Moshannon	9/25/75 9/15/76 3/30/73	804,814	673,330	1,478,144	Shut-In Shut-In Producing
Clinton & Potter.....	Leidy	TOTAL Ole Bull	1/ 9/50 1/ 9/59	160,224,061 5,424,029	14,095 14,095	160,238,156 5,438,124	Gas Storage & Producing Producing
Crawford.....	Athens Cambridge Springs Geneva Sparta	Greenwood Eastman Hill	9/20/74 1/31/76 10/31/73 10/30/75		39,043	39,043	Shut-In Producing Shut-In Shut-In
Crawford & Erie.....	Conneaut	TOTAL Bushnell- Lexington Indian Springs Kastle Lundys Lane Pierce West Mead	2/11/57 12/31/58 9/11/57 7/14/62 11/ 9/61 12/31/58 7/ 8/74	35,055,983 15,269,934 13,452,865 3,137,408 2,005,551 811,232 3,262	1,470,825 542,936 624,110 79,083 205,413 19,223	36,526,808 15,812,930 14,076,975 3,216,491 2,210,964 830,455	Producing & Abandoned Producing & Abandoned Producing Producing Producing Producing Shut-In
Elk.....	Benzinger Horton	Boot Jack	11/ 7/72 9/20/73	6,249	3,001	9,250	Shut-In Producing
Erie.....	Alder Run Bull Reservoir Burgess Corry Mckean Northeast	TOTAL Beaver Dam Orchard Beach	10/30/75 9/17/72 10/17/60 4/29/47 5/20/53 12/19/73 2/ 8/74	158,959 1,060,075 206,375 129,876	2,585 1,746 1,746 4,993 13,500	161,544 1,061,821 208,121 134,869 13,500	Shut-In Producing Producing Gas Storage & Producing Producing Producing Producing
Fayette.....	Highhouse Ohiopyle Sandy Creek*	Woodside Fike Quebec Run	3/10/75 12/28/59 8/ 8/63 8/ 8/63 6/31/69	4,197,523 610,565 429,142 181,423	73,699	4,271,222	Shut-In Producing Shut-In Shut-In Shut-In
	Spruell Summit	TOTAL North Summit South Summit	10/31/61 3/24/38 2/25/38 5/ 9/42	4,528,833 43,253,973 21,302,362 21,924,461	640,072 229,611 102,289 127,322	5,168,905 43,483,584 21,404,651 22,051,783	Producing Producing & Abandoned Producing Producing
Indiana.....	Cherry Hill*	Crichton Hadden	1/ 9/63 7/11/63	2,907,586	36,185	2,943,771	Producing
	Jacksonville Nolo Strongstown		9/21/56 9/30/56 12/20/69	28,965,836 13,552,803 4,600,705**	246,100 130,194 2,942,081	29,211,936 13,682,997 7,542,786	Producing Producing Producing
Jefferson.....	Big Run*	Elk Run	6/30/65	46,720,000	426,399	47,146,399	Producing
Lycoming.....	Salladasburg		6/24/76				Shut-In
McKean.....	Bradford Corydon	Cyclone Minard Run	2/18/74 1/10/75 9/ 8/72	336,600	152,413	489,013	Producing Production not available Shut-In
Mercer.....	Henderson Sheakleville Wheatland	Kilgore Fleck	10/26/66 8/27/75 7/24/63	205,024**	17,716	222,740	Production not available Shut-In Producing
Potter.....	Ulysses	New Field	10/ 2/39 4/ 2/63	3,971,494	96,277	4,067,771	Producing
Somerset.....	Boswell	TOTAL Boswell Snyder	11/11/58 11/11/58 6/16/60 9/22/73	11,518,994 10,538,962 980,032	180,726 163,478 17,248	11,699,720 10,702,440 997,280	Producing Producing Producing Shut-In
Venango.....	Barkeyville Franklin-Oak Forest Wesley	Duncan Galloway Irwin	4/ 5/73 11/12/73 12/ 1/72	74,238 26,621** 106,134	14,240 8,131 41,121	88,478 34,752 147,255	Producing Producing Producing
Warren.....	Sugar Grove Whites Run	Pettigrew	5/29/70 10/30/75				Shut-In Shut-In
Washington.....	Daniels Run*	Glyde	9/ 6/61	115,149	5,944	121,093	Producing
Westmoreland.....	Blairsville* Latrobe* Jacobs Creek* Lycippus	Kahl Ory Ridge Bailey TOTAL St. Boniface	10/23/62 8/25/46 12/26/61 8/17/49 9/13/56	9,800,459 5,377,203 1,793,791 6,359,335	282,640 205,993 107,842 123,696	10,083,099 5,583,196 1,901,633 6,483,031	Producing Producing Producing Producing & Abandoned
	Murrysville*	Chapel TOTAL Ouquesne	11/ 3/1878 11/ 8/65 8/ 8/65	5,619,907 650,351 521,424	123,696 37,326 37,326	5,743,603 687,677 588,750	Producing Producing & Abandoned Producing
Westmoreland & Somerset.....	Johnstown	TOTAL Baldwin Beck Williams TOTAL Blair Tunnel Seven Springs	5/16/57 5/22/60 5/16/57 2/14/58 12/15/58 12/ 5/58 3/10/65 8/ 3/66	27,142,174 9,745,007 17,397,167 7,386,489 6,032,519 641,547	807,646 400,556 407,090 79,761 53,257 26,504	27,949,820 10,145,563 17,804,257 7,466,250 6,085,776 668,051	Producing & Abandoned Producing & Abandoned Producing Producing & Abandoned Producing Producing

\*\*Shallow\* Gas Production of Field Not Shown

\*\* Correction

Table 12. *Oil Wells and Crude Oil Produced in Pennsylvania by Counties, 1974 and 1975\*\**

County	Crude oil production (barrels)		Number of producing oil wells	
	1975	1974	12/31/75	12/31/74
Allegheny.....	58,848	61,898	342	340
Armstrong.....	12,263	11,859	124	120
Beaver.....	4,342	4,572	105	105
Butler.....	77,595	78,817	1,346	1,356
Clarion.....	23,264	24,087	512	541
Crawford..... *	67,367	* 60,198	452	450
Elk.....	24,239	36,565	213	213
Erie..... *	470	* 257	5	5
Fayette.....	139	159	2	2
Forest.....	137,656	125,909	823	761
Greene.....	32,237	31,589	277	287
Jefferson.....	2,714	2,392	108	109
McKean.....	1,506,538	1,680,120	13,264	13,226
Mercer.....	5,506	15,943	99	99
Potter.....	17,207	12,650	196	190
Venango.....	549,214	503,638	9,673	9,630
Warren.....	489,516	509,817	3,979	4,078
Washington.....	99,529	105,042	536	583
TOTAL.....	3,108,644	3,265,512	32,056	32,095

\*Corning grade crude. All the rest of the crude produced is Penn Grade Crude.

\*\*Compiled by the Department of Commerce, Bureau of Statistics

### Land Sales

At the end of 1976 the Pennsylvania Game Commission had 38 active leases totaling 35,039 acres compared with 44 active leases at the beginning of 1976. Six leases in Clarion, Erie and Mercer Counties were surrendered during the year by 4 public utility gas companies. On 12 of the 38 leases there were 41 producing gas wells whose total production amounted to 342,329 Mcf for 1976.

In 1976, the total income from oil and gas programs of the Department of Environmental Resources which cover royalties, gas storage and exploratory acreage rentals, pipeline rights-of-way and seismic permits will total \$717,212.11. Of this total, royalty payment for the year amounted to \$243,898.07 for 2,186,611 Mcf. The reason for the increase in this income and production was due to the advance payment for the remaining gas reserves located on State Forest lands in the Driftwood-Benezette gas storage field, Elk, Clearfield and Cameron Counties. The payment for the

Table 13. *Crude Oil Prices per Barrel, Pennsylvania, 1976*

Month	Upper Tier (Stripper Wells and New Crude)			
	<i>Bradford District</i>	<i>Middle District</i>	<i>Southwest District</i>	<i>Corning</i>
January	\$13.07	\$12.70	\$12.55	\$12.92
February	11.05	10.68	10.53	10.90
March	11.12	10.75	10.60	10.97
April	11.19	10.82	10.67	11.04
May	11.26	10.89	10.74	11.11
June	11.32	10.95	10.80	11.17
July	11.32	10.95	10.80	11.17
August	11.32	10.95	10.80	11.17
September	13.82	13.82	13.82	13.82
October	13.82	13.82	13.82	13.82
November	13.82	13.82	13.82	13.82
December	13.82	13.82	13.82	13.82

1,651,779 Mcf of reserves totaled \$201,278.17. Rentals for existing wildcat acreage and past leasing programs totaled \$99,283.66 while storage rentals were \$360,763.13. Other income for pipelines, compressor station rentals and seismic surveys totaled \$13,267.25.

During the year, the only new State acreage placed under lease was an oil and gas lease for 618 acres which was obtained by land acquisition in the Tiadaghton State Forest, Lycoming County.

At the end of the year, 253,677 acres of State Forest and Park lands were currently under lease for oil and gas exploration and development. This figure includes 98,611 acres in gas storage and a 3,784 acre tract in Clearfield County which contains seven gas wells which are operated by the Department.

The only wildcat well drilled in 1976 on State Forest lands was located on Tract 210 in the Elk State Forest, Cameron County. This well was drilled through the Oriskany sandstone but was dry and plugged.

## Geophysical Activity

The Department issued one seismic permit to industry to conduct subsurface studies to evaluate an area for possible oil and gas exploration in Susquehannock State Forest, Potter County.

Seismic activity was down from 50 crew-weeks in 1975 to 40 crew-weeks in 1976, with the activity being about 50 percent Vibroseis and 50 percent conventional. The total cost of the seismic work was about \$1,125,000. Seismic surveys were made in Butler, Clarion, Clearfield, Clinton, Crawford, Indiana, Jefferson, Mercer, Potter, Tioga, Venango, and Warren Counties, 12 of the 67 counties in the commonwealth.

## 1976 Highlights

Discoveries were up to 17 which is one more than in 1975. Of the 17 discoveries, 10 were gas and 7 oil. Contributing to the deep well activity in Crawford County was the discovery of the Greenwood field by the No. 1 Kebert Developers of N-Ren Corporation. The well found gas in the Medina (Lower Silurian) with an initial open flow of 1,229 Mcfgpd at a rock pressure of 1297 psi in 48 hrs. By the year's end, 8 gas producers had been drilled and a ninth well had to be plugged and abandoned due to collapsed casing.

Another discovery in the county was the No. 1 John F. Tobin by Van Raalte Oil Company, which found gas in the Medina with an initial open flow of 2,200 Mcfgpd at a rock pressure of 1221 psi in 48 hrs., discovering the Cambridge Springs field. At the close of the year 2 gas producers and 2 dry holes had been drilled in this field. The Indian Springs field was also active in this county with 6 oil and gas wells completed in the Medina during the year. This activity is a continuation of the search for production in the Medina of northwestern Pennsylvania. Activity will continue in this area as more industrial concerns who have plants in the area continue to search for gas to supplement the gas they purchase from the gas utilities.

The Tomb's Run Anticline in Lycoming County was tested for gas during 1976 by the No. 1 Mary Louise Hess well of John H. Ware, III. The well discovered the Salladasburg field, with production from the Oriskany (Lower Devonian) amounting initially to 1,100 Mcfgpd at a rock pressure of 3800 psi in 4 days. The Tomb's Run Anticline as mapped on the top of the Lock Haven (Chemung) Formation has a length on the surface of about 23 miles and a closure of at least 500 feet. The discovery well is located well down on the flank of the structure. If structure at depth is the same as the surface structure, this discovery could be very significant.



The No. 1 James E. Fleck by Peoples Natural Gas Company in Mercer County was drilled into Precambrian granite at 9,130 feet and ended at a total depth of 9,246 feet. The well was located on a seismic and surface delineated structure. It was plugged back and fractured in the Medina sandstone from 4,990 to 5,040 feet, discovering the Fleck pool in the Sheakleyville field. The initial production was 231 Mcfgpd at a 5 day rock pressure of 1360 psi. This well may become one of the wells to be tested for possibilities of Upper Devonian shale gas production in the ERDA shale gas project.

An Upper Devonian Gantz sand gas discovery in Washington County had an initial natural production of 18,600 Mcfgpd at an 8 day rock pressure of 900 psi, becoming the largest producer of gas that the state has had in the last few years. The well is the No. 1 Hallie E. Taylor by Peoples Natural Gas Company. It discovered the Granville pool in the Bellevernon field.

The No. 1 Metropolitan Industries Upper Devonian shale gas well, drilled by Quaker State Oil Refining Corporation in Beaver County and reported in the 1975 development report, did not last long when put on line. The well delivered 150 Mcf the first day and declined each day thereafter until at the end of 30 days the well was non-productive. When shut-in, pressure would build up, but on opening up the well, it would blow off to nothing in a short time. Evidently, there was very little original fracture porosity. Gas accumulated mainly in fractures induced when the well was completed by hydraulic fracturing.

As in 1975, the major deep activity during 1976 was in northwestern Pennsylvania in the Medina play while the Indiana County area again has been the most active in shallow drilling. These two areas will probably continue being active in 1977.

## INDUSTRY RELATED ACTIVITIES

### Subsurface Base Maps

Twenty-three base maps (Figure 8) showing locations of oil and gas wells and the outlines of the oil and gas fields are now available. Each base map encompasses four 15-minute topographic quadrangles and is at the same scale (1 inch equals 1 mile). A five-minute grid, quadrangle names, county boundaries, and major rivers and towns make up the background of the base map. All deep wells known and all shallow wells on record with the Pennsylvania Geological Survey are located, and the status (dry, oil producing, gas producing, etc.) is shown by symbol. Deep wells (Tully Formation or deeper) are differentiated and elevation and total

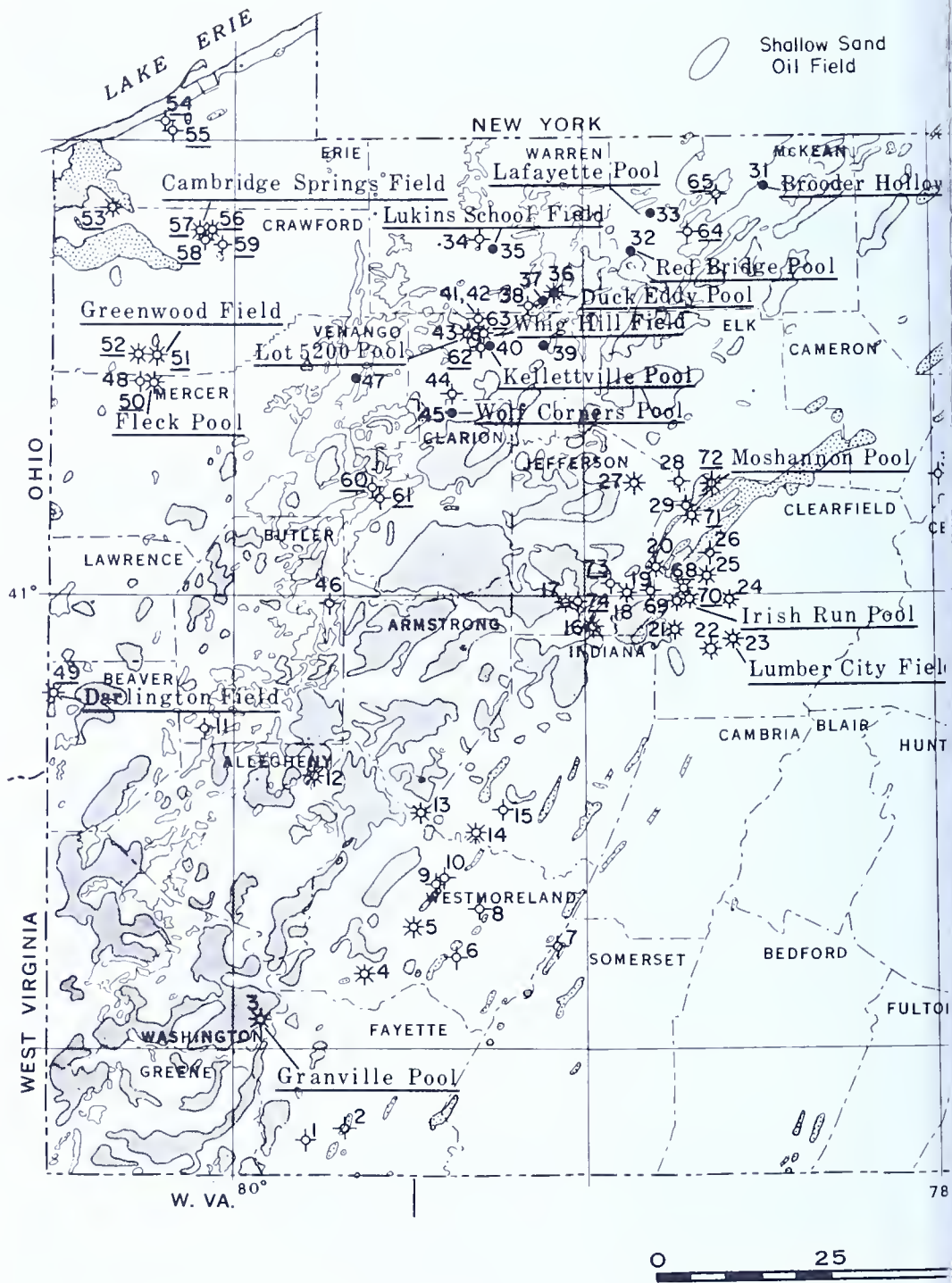
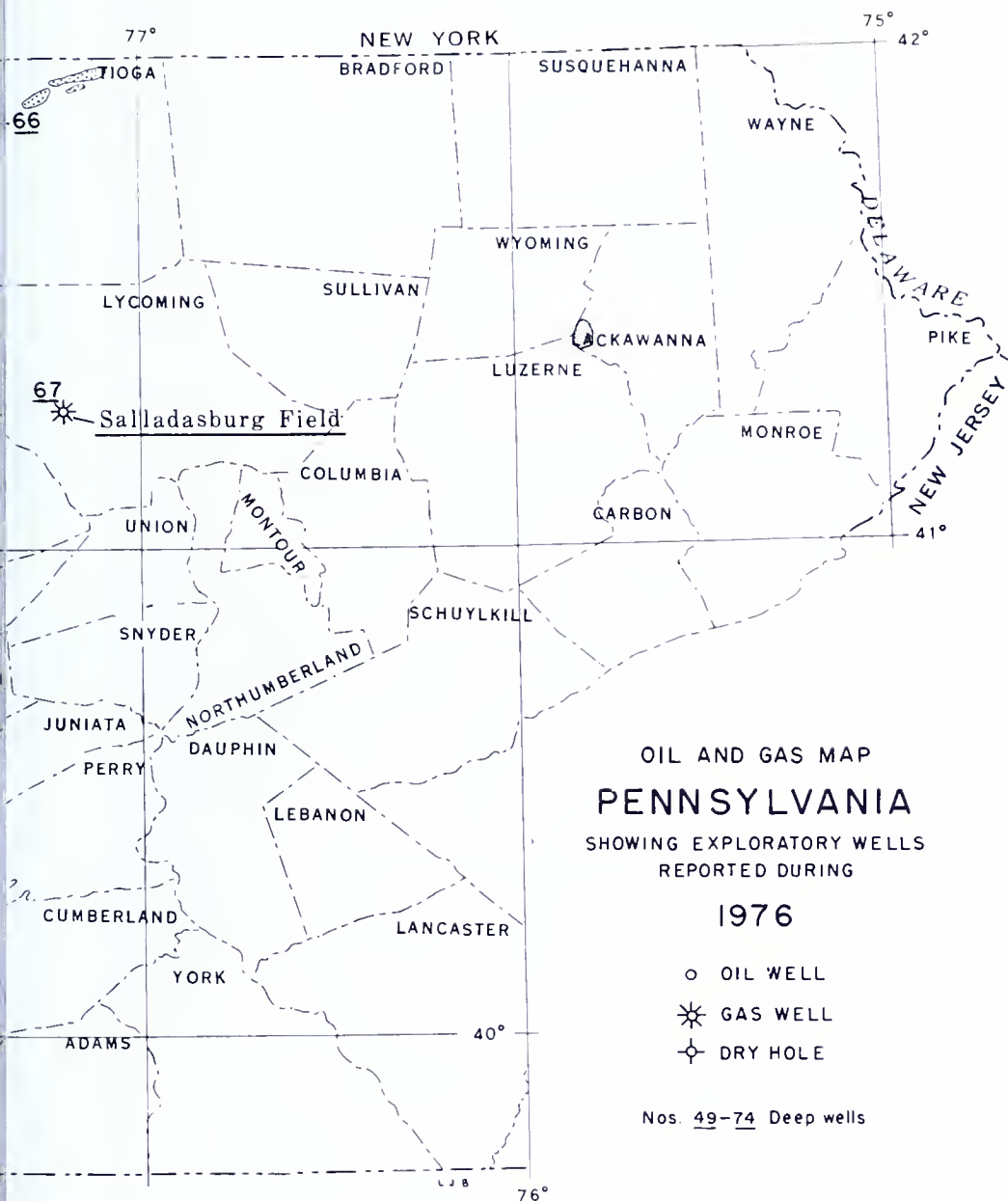


Figure 4. Oil and gas map

Sand  
eldDeep Sand  
Gas Field

75 100 miles

showing exploratory wells

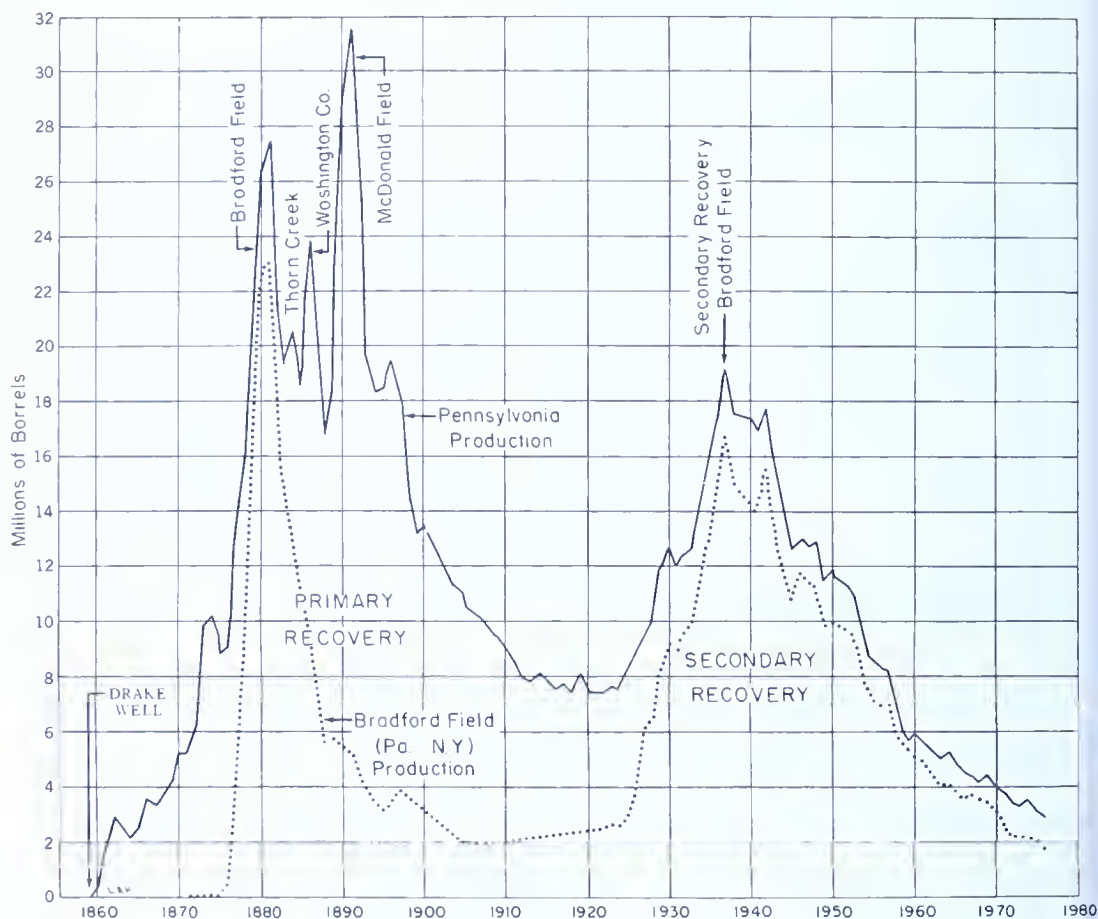


Figure 5. Annual production of crude oil in Pennsylvania.

depth are shown. Symbols indicate the availability of geophysical log and sample data on open file in the Survey's Oil and Gas Geology Division office in Pittsburgh. An index map with the legend shows the outlines of oil and gas fields within the mapped area, thus indicating areas of extensive pre-1956 drilling. A listing of the field names is also included.

Paper prints of the base maps can be obtained by writing to the State Book Store, P. O. Box 1365, Harrisburg, Pennsylvania 17125. The cost of each base map is \$0.50, plus a 6 percent sales tax to Pennsylvania residents. A check for the appropriate total amount made out to the Commonwealth of Pennsylvania must accompany the order. When ordering please specify the map number.

A cross index of state permit numbers with quadrangle map numbers used on the base maps is available from the Pittsburgh Branch of the Pennsylvania Geological Survey, 1201 Kossman Building, 100 Forbes Ave., Pittsburgh, Pennsylvania 15222. This index is arranged by quadrangles.

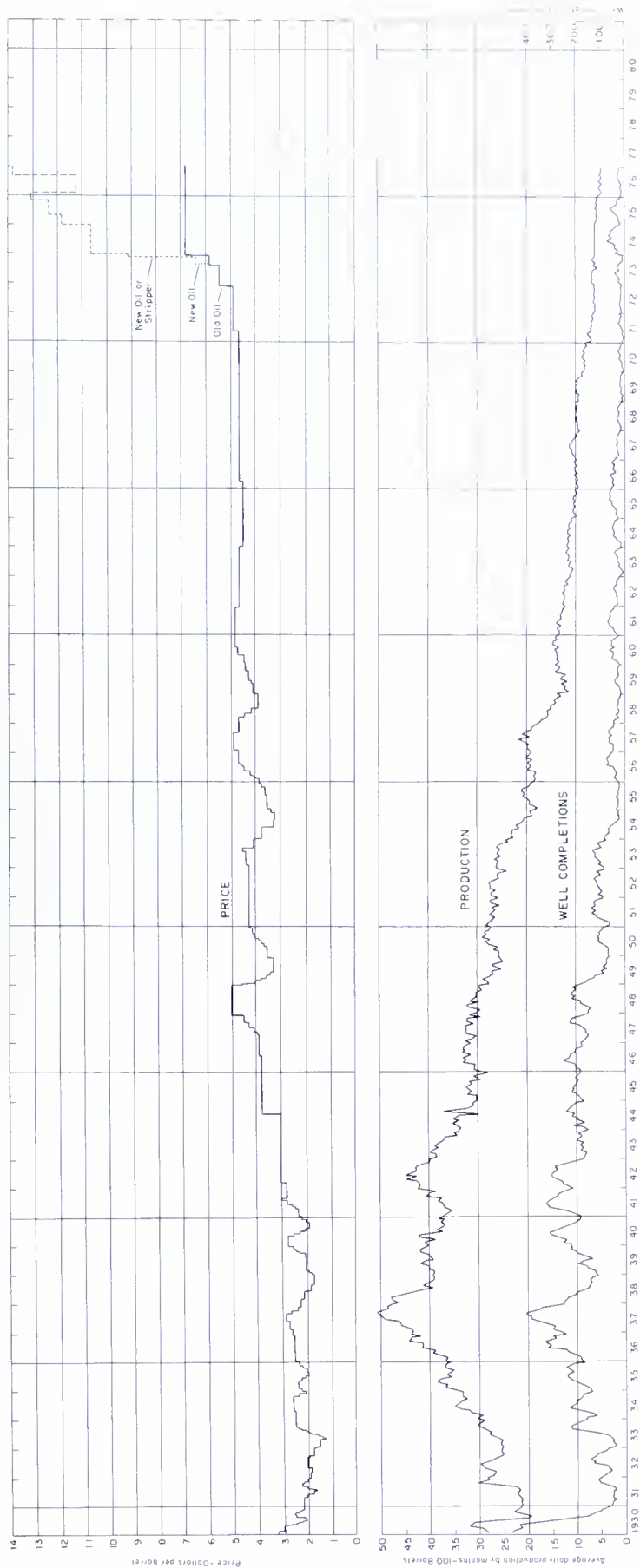


Figure 6. Crude oil prices, production and completions, Bradford District.



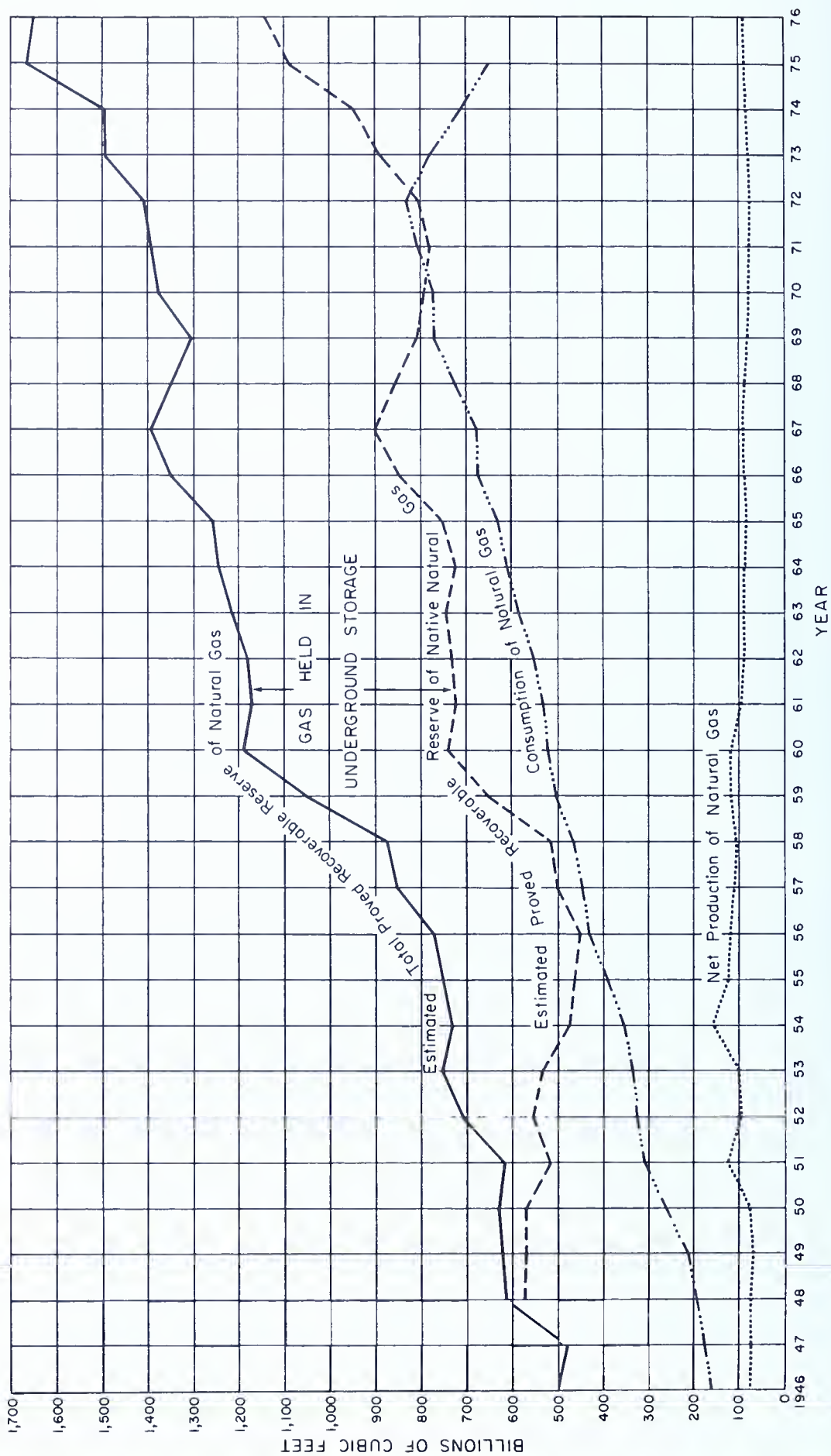


Figure 7. Production, consumption and reserves of natural gas in



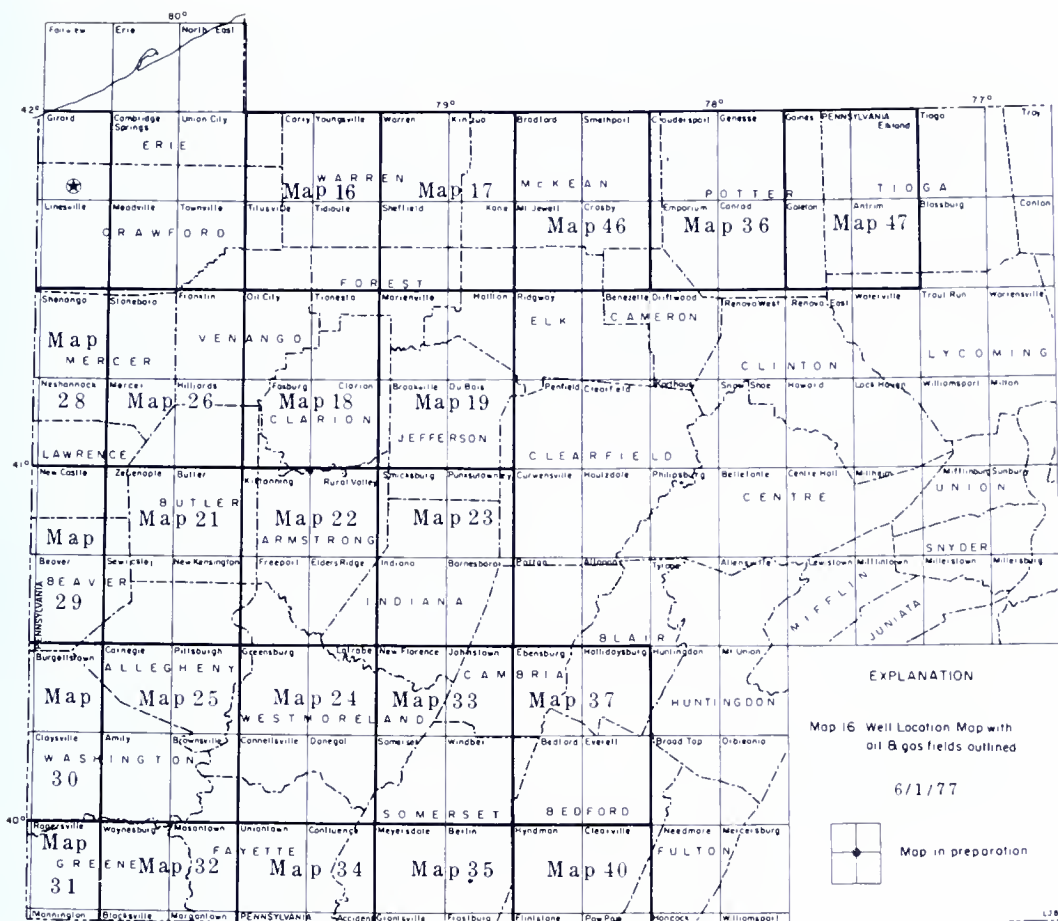


Figure 8. Index of available subsurface base maps.

Please specify the quadrangle when requesting this literature. Base maps are updated every year. Maps now available were updated as of June 1, 1977. A list of the Survey's publications and open file reports can be obtained by sending a request to either the Pittsburgh or Harrisburg office.

### PART III. OIL AND GAS GEOLOGY DIVISION STUDIES

#### SUBSURFACE ROCK CORRELATION DIAGRAM, ALLEGHENY PLATEAU OF PENNSYLVANIA

By Louis Heyman

The diagram, Figure 9, is intended to summarize the present level of understanding of the regional rock stratigraphy from Middle Devonian



1) The ambiguous stratigraphic relations of limestones heretofore lumped as Tully in the subsurface. Rickard (1975) and Wright (1973) emphasize the existence of a hiatus in New York below the true Tully from west-central New York westward, and where the true Tully is absent, at the base of the Upper Devonian. The New York workers consider the top of the Middle Devonian in the western areas to be bounded by an unconformity, with limestones progressively lower in the Hamilton Group miscalled Tully in the subsurface. Thus, regional subsurface maps using Tully as a datum should be regarded skeptically.

2) Onondaga (Edgecliff) reefs have been recognized in the subsurface in McKean County, northern Pennsylvania and have been discussed by Piotrowski (Lytle and others, 1976).

3) A newly recognized unit, the Bois Blanc Formation, is located below the Edgecliff (Lower Onondaga). It rests unconformably on Ridgeley or lower units in the northwestern Pennsylvania subsurface. It apparently thins and becomes more clastic eastward, wedges out in eastern McKean County, and merges by facies change into the lower Huntersville-Needmore south of Mercer-Clarion Counties. In position, it apparently is the western counterpart of the Schoharie Formation to the east.

4) Oriskany sandstone as previously mapped is at present understood to include four discrete sandstone units in the subsurface of the Plateau. The Ridgeley ("Oriskany") sandstone proper is conformable on lower rocks in south central and southwestern Pennsylvania, but is probably increasingly unconformable on progressively lower rocks northwestward. In a small area of Fayette and Somerset Counties, a sandstone unit down in the Helderberg carbonates has been called "Second" or "Lower" Oriskany. At least in parts of Erie County, local areas of Ridgeley sandstone have been preserved from pre-Bois Blanc erosion by structure which is apparently related to local absence of salt in the Salina B unit (Kelley and McGlade, 1969). The Bois Blanc locally contains basal sandstone lenses which have been called Oriskany. These sand lenses unconformably overlie rocks from as low as upper Silurian Bass Islands Group up to the Ridgeley.

5) The upper part of the Shriver Formation grades vertically and laterally into the lower Ridgeley. The remainder of the Shriver grades laterally into the Licking Creek (upper Helderberg) limestone, and the formation as a whole appears to be largely a Helderberg rather than an Oriskany equivalent. Eastward, the Shriver occupies an increasing portion of the interval between the Ridgeley and the Mandata shale. The sub-Mandata-Helderberg Group includes a varied carbonate facies which in part is laterally correlative with the upper Keyser limestone.

6) Facies changes and relationships between the Salina Group to the northwest and the Tonoloway-Wills Creek- (upper) McKenzie sequence to

the southeast can be demonstrated by tracing several persistent Salina shale tongues for great distances southeast. These include the Camillus shale interval in the lower part of the Salina G unit, the shale interval in the upper part of the Salina E unit, and the Salina C shale, a remarkably persistent unit identifiable from the Michigan Basin southeast into west-central Pennsylvania, where it merges into the upper Wills Creek Formation.

7) A tongue of the Bloomsburg Formation protrudes westward well beyond the main body and apparently divides upper McKenzie from lower Wills Creek. It is sandy in a small area in southwestern Pennsylvania and here may be the most northerly extension of the Williamsport sandstone of West Virginia.

8) The "reef" or biohermal facies of the Lockport apparently is a downward thickening of the Salina A1 carbonate at the expense of the upper Lockport dolomite, rather than a protruding Lockport pinnacle. The total thickness of the Salina A1 plus the Lockport is very uniform over large areas. The DeCew shale member, the lowermost unit of the Lockport, grades down into the underlying Rochester shale, while the lower part of the latter can be traced laterally southeastward into the Rose Hill Formation. The Rose Hill and Rochester in many areas are separable only where the Keefer sandstone is recognizable between them.

9) The Tuscarora sandstone grades down into a reddish, locally argillaceous, quartzose sandstone which is here considered a Tuscarora-Juniata transition. The Tuscarora-Juniata-Bald Eagle relationship in the subsurface is poorly understood. The Whirlpool sandstone in the subsurface in Erie and Crawford Counties is a basal unit lying unconformably on Queenston redbeds, but south and eastward probably coalesces into a westward protruding tongue of the Tuscarora. To the southeast, the lower Tuscarora is almost certainly lower stratigraphically than the "basal" Whirlpool of the northwest.

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## DEVONIAN SHALE RESEARCH IN PENNSYLVANIA

By Robert G. Piotrowski and Stephen A. Krajewski

The Energy Research and Development Administration (ERDA) has embarked upon a five year study of the Devonian organic-rich shales of the Appalachian Basin (Figure 10). The project is managed by W. K. Overbey of ERDA's Morgantown Energy Research Center. The resource evaluation portion of the project of which the Oil and Gas Geology Division of the Pennsylvania Geological Survey is a part, is managed by Assistant Project Manager Arlen Hunt. The work done by the Pennsylvania Survey will be under the direction of Wallace DeWitt and John Roen of the U. S. Geological Survey.

The purpose of the study is twofold. The first objective is resource evaluation and research into the controls that affect the accumulation of hydrocarbons within these shales. This includes the preparation of stratigraphic cross sections and maps showing thickness and extent of black shales and other related rock units, maps showing the structural setting of these rock units and maps indicating known hydrocarbon shows and production from the black shales, as well as the examination of outcrop samples, cores and well cuttings for mineralogy, organic carbon content, trace-element composition, maturation and physical properties. These data will be used to prepare maps and reports which will indicate resource base and reserves of gas under different production modes.

The second portion of the study is designed to increase the production of gas from known reserves in the shales by development and implementation of new drilling and production techniques. This technology development includes investigating new geophysical and geochemical methods for locating fractured reservoirs, investigating various methods of modifying the shale matrix to increase the rate of gas flow, deriving predictive models for fracturing techniques using explosives and various hydraulic fluids, and testing several state-of-the-art techniques of hydraulic and explosive fracturing as well as directional drilling to intercept natural fracture systems. (A listing of all participants and a summary of all contracts is available in the report: *Summary of Contracts for Eastern Gas Shale Project* published by the U. S. Energy Research and Development Administration, Morgantown Energy Research Center, Morgantown, West Virginia.)

The Oil and Gas Geology Division of the Pennsylvania Geological Survey is involved in a portion of the resource evaluation phase of this project. Specifically, the Survey is contracted to: (1) Identify all wells in Pennsylvania which penetrate the Devonian shale section and to indicate all wells in which shale-gas production or shows were reported.

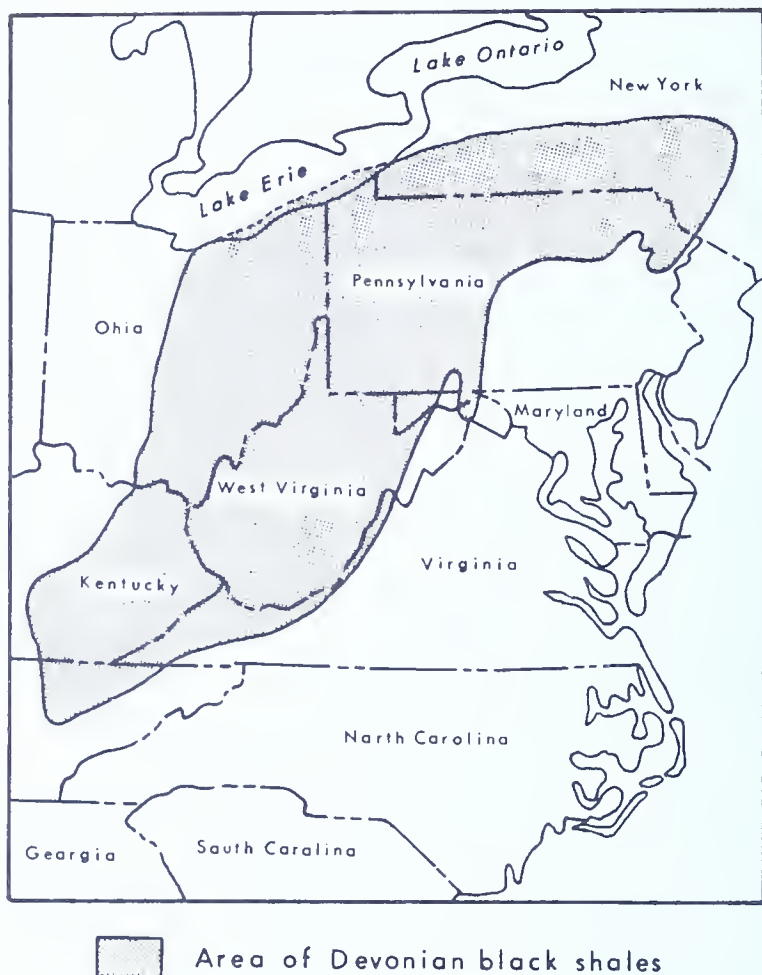


Figure 10. Area of Devonian black shales to be studied for natural gas by USGS, ERDA, state geological surveys and universities.

(2) Provide a stratigraphic framework for the predominantly clastic sediments between the Berea-Cussewago-Murrysville interval (approximate Mississippian-Devonian boundary) and the top of the Onondaga limestone of Middle Devonian age. (3) Define and map the black-shale facies and related rocks within this sequence in order to understand their sedimentological history and to help in predicting and evaluating potential gas resources in the Devonian shales. (4) Provide a subsurface structural picture of the black-shale facies and related rocks in Pennsylvania. (5) Provide and maintain a storage site for all data and cores obtained in Pennsylvania from the Devonian shale project. (6) Encode stratigraphic and structural data generated in Pennsylvania by this project in a computer retrieval format.



The geological evaluation done by the Oil and Gas Geology Division will be the framework upon which all other portions of the resource inventory subproject of the Eastern Shale Gas Project in Pennsylvania are based. All physical characterization, geochemical characterization and resource assessment projects in Pennsylvania will build upon the initial framework of this geologic evaluation.

During the past year several objectives of the Devonian Shale Project have been accomplished. First, a map is in preparation which indicates all wells which penetrated the Onondaga and all wells which had a *reported* show or production of natural gas from the Devonian organic-rich shales. All the known production, both recent and old, and all the reported shows from the shales are indicated in Figure 11.

An old shale-gas producing area is indicated along Lake Erie in the Erie, North East and Girard fields. Natural gas was produced from low pressure wells in these fields between 1821-1880, and historical records indicate similar production all along the Lake from Dunkirk, New York, to Sandusky, Ohio. The field outlines are taken from old maps and locations or drillers' logs are not available. Because the gas was used locally, the fields may simply define major population areas and the old production may actually extend all along the Lake.

Many new wells also had gas shows in the Lake Erie area. A recent shale discovery well was drilled and completed in 1976 in the old North East field. This well, the Welch Foods, Inc. #3 had an initial potential of 12 Mcfgpd before fracture and 150 Mcfgpd after fracture with an 80 lb. rock pressure. The old production along the Lake is believed to have been similar to the production from this well.

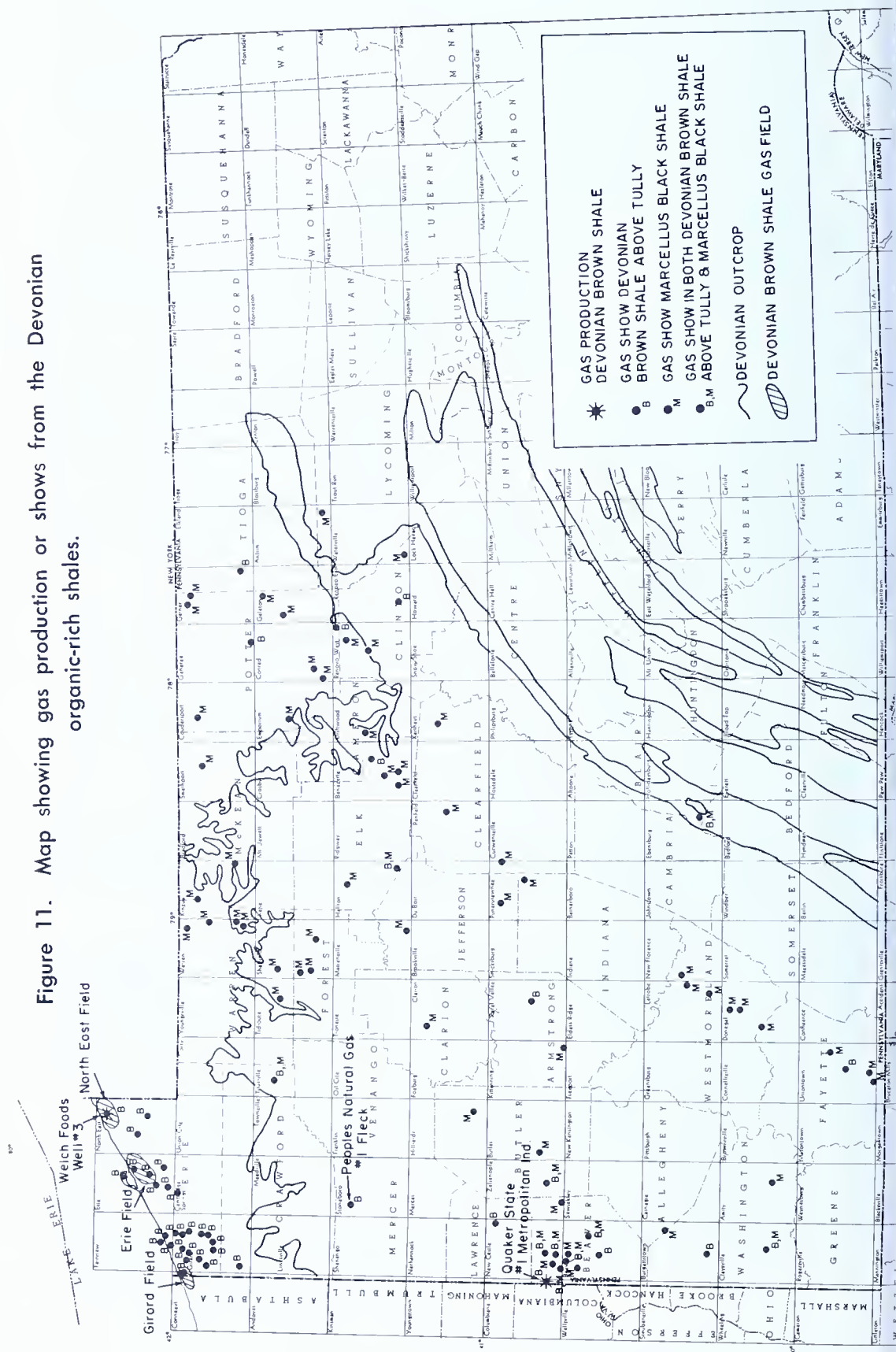
The second area with numerous shale-gas shows is in Beaver County (Figure 11). In this area, the #1 Metropolitan Industries well was completed by Quaker State in May, 1975. This well had no natural open flow; however, after fracture it had an initial potential of 150 Mcfgpd with a 1150 lb. rock pressure.

Other than along Lake Erie and in Beaver County, most of the shale-gas shows are reported from the Marcellus. No commercial production from the Marcellus is known, but the shows are quite widespread throughout the study area.

A drilling depth map at a scale of 1:250,000 is also in preparation. This map shows the outline of the Devonian sedimentary basin and the contoured depth to the Onondaga. The map will show the drilling depth necessary to test the organic-rich shales of this study and will help in estimating drilling cost.

In addition to these maps, a series of nine stratigraphic cross sections based upon gamma ray logs have been constructed for the study area

Figure 11. Map showing gas production or shows from the Devonian organic-rich shales.



(Figure 12). The cross sections are at a scale of  $1'' = 100'$  and provide a framework for the rock units between the Berea-Cussewago-Murrysville interval which is approximately the Mississippian-Devonian boundary and the top of the Onondaga of Middle Devonian age.

The gamma ray log on which the stratigraphic cross sections are based is a record of the measurement of the natural radioactivity of the rocks penetrated by the bore hole. Nearly all of the gamma radiation encountered in the earth is emitted by the radioactive isotope potassium of atomic weight 40 ( $K^{40}$ ) or the radioactive elements of the uranium and thorium series. In sedimentary formations, the gamma ray normally reflects shale content, because  $K^{40}$  is usually more concentrated in the shale. In contrast, clean non-shaly formations usually have a very low level of radioactivity. Thus, sandstones can be differentiated from shales on the gamma ray log.

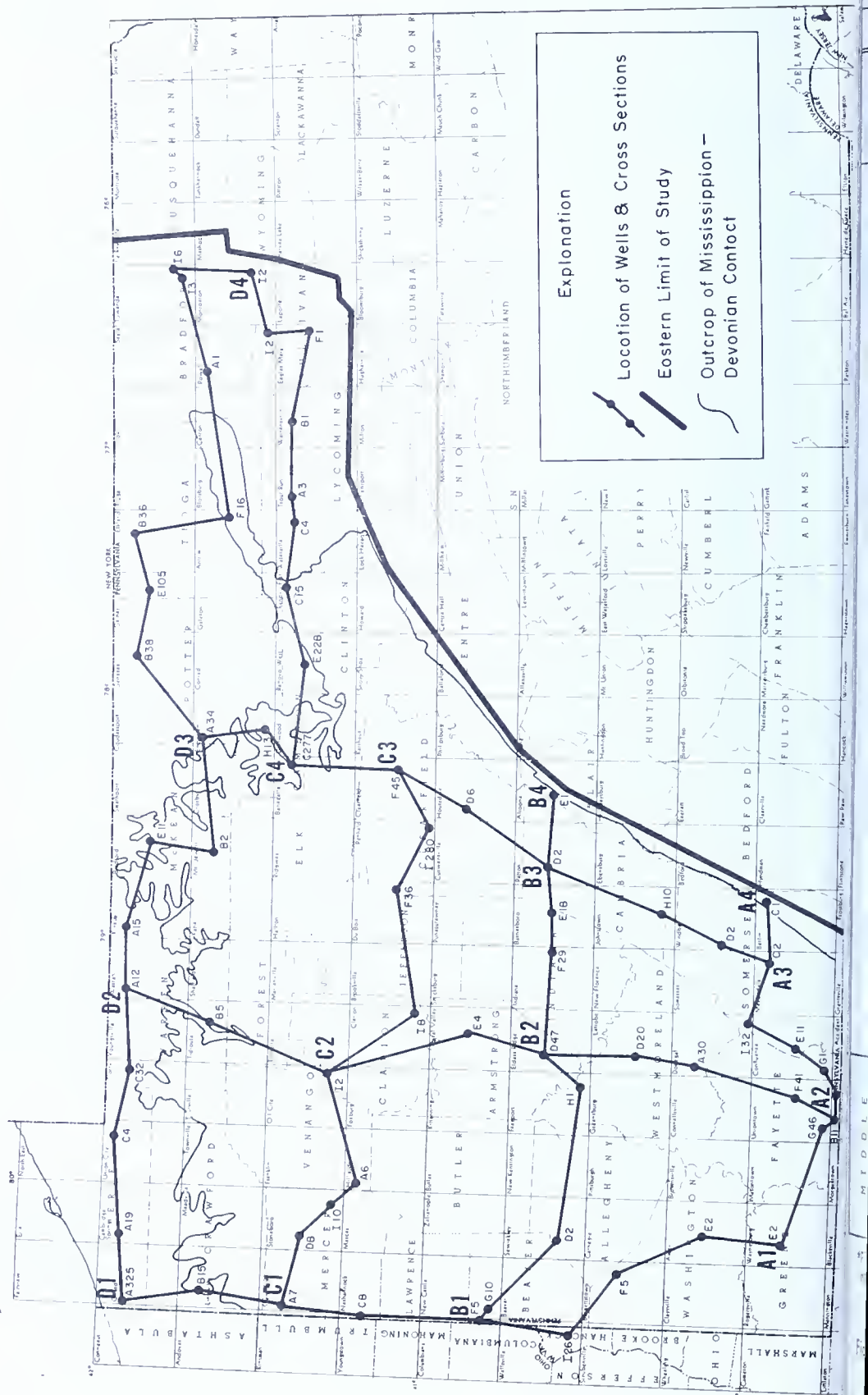
Studies of uraniferous shales have shown that dark-colored organic-rich marine shales have a higher than average uranium content as compared with lighter colored shales. The apparent reason for this empirical relationship is that the presence of organic matter in the sediment causes preferential precipitation of uranium from sea water. Thus, relatively high gamma ray responses could define organic-rich shales with high uranium content.

Formation density is another factor which has an important effect on the gamma ray response. Gamma rays are gradually absorbed and their energies degraded as they pass through rocks and the amount of absorption is known to vary with rock density. Thus, high radioactive responses may reflect low density which could be caused by mineralogical changes or fracturing.

In this study, the shales which are called black or organic rich are the high radioactive zones as defined by the gamma ray log. It is believed that this response is due primarily to high organic content with some possible relationship to fractures. It is also known empirically that there is a direct relationship between high radioactivity and natural gas production from shales in West Virginia, Kentucky, Ohio and Pennsylvania, and that gamma ray log responses generally can be correlated to lithic changes observed in sample descriptions. The sandstones are defined in this study by relatively low gamma ray log responses. Gamma ray logs were also employed because they are commonly run in most Pennsylvania wells, are readily available, and can be interpreted consistently.

Figure 13 is a generalized stratigraphic column, and Figure 14 is a schematic section of cross section C1-C3 (Figure 12). The generalized section and the schematic show the major subdivisions of the Middle and Upper Devonian as defined by the gamma ray logs used in this study. These units will also be used for regional mapping.

Figure 12. Index map showing the location of nine stratigraphic cross sections in Pennsylvania and the limits of the study area. The approximate Mississippian-Devonian contact in Pennsylvania is also shown.





AGE	ZONES	UNITS	SANDSTONE NAMES*
MISSISSIPPIAN		Big Injun	Loyalhanna Big Injun-Mountain Burgoon
	MIDDLE AND LOWER POCONO		Shenango, Slippery Rock, Squaw Second Gas Berea, Cussewago, Corry, Knapp, Murrysville
UPPER DEVONIAN	D UPPER SAND ZONE	D 3	Riceville Shale in north-central Pa. Venango First, Hundred Foot, Fifty Foot, Gantz, Drake, Tuna Red Valley, Lytle, Rosenberry, White, Salamanca
		D 2	Venango Second, Salt, Upper Nineveh, Lower Nineveh, Snee, Shira, Boulder Venango Third Stray, Venango Third, Venango Fourth (Fourth), Venango Fifth (Fifth), Venango Sixth (Sixth), Grey, Black, Green, Gordon Stray, Gordon, McDonald Fourth, McDonald Fifth, Knox Third Stray, Knox Third, Knox Fourth, Knox Fifth, Wolf Creek, Clarion, Byram, Conewango, LeBoeuf, Magee Hollow
		D 1	Bayard Elizabeth
	C SHALE ZONE		
	B MIDDLE SAND ZONE	B 4	Warren First Warren Second Queen Glade, Bradford First, Eighty Foot, Clarendon Stray
		B 3	Clarendon, Sugar Run, Watsonville, Dew Drop, Chipmunk, Cherry Grove, Gartland, Upper Balltown, Lower Balltown, Speechley
		B 2	Tiona, Cooper Stray, Cooper Bradford Second Klondike, Harrisburg Run Deerlick, Sliverville
		B 1	Bradford Third Lewis Run Upper Kane Lower Kane Sartwell
	B o LOWER SAND ZONE	Undivided	Haskill, Reily, Elk Humphrey, Benson, Alexander
	A SHALE & SILTSTONE ZONE	Zone II Facies	
		--- Second marker ---	
		Zone I Facies	
		--- First marker ---	
		Burkett Black Shale	
MIDDLE DEVONIAN	TULLY	Erosional Unconformity in northwest Pa.	Tully Limestone
	HAMILTON	Driller's Tully (?Centerfield & Tichenor of N. Y.)	
		Mahantango Marcellus Black Shale	
	ONONDAGA	Onondaga Ls	Huntersville Chert / Selinsgrove Ls Needmore Shale

\*Placement of sand names refers only to position of the sand in area where it was first named or used.

Figure 13. Generalized stratigraphic column Middle and Upper Devonian of western Pennsylvania.





The fine-grained clastics which succeed the Tully are informally designated zone A. The major black shales, zone I facies and zone II facies, and the minor black shales which are the Burket, first marker and second marker are subdivisions of zone A. These black shales are seen to grade lithologically from west to east and are overlain by grey shales and siltstones which make up most of zone A. The Burket black shale directly overlies the Tully. It is a relatively thin unit but is regionally persistent, and is approximately equivalent to the Genesee shale of New York. The first marker unit of this study is a relatively low radioactive zone, but persistent in northwestern Pennsylvania. The first marker is approximately equivalent to the Middlesex shale of New York. The zone I facies is the second major black shale unit in Pennsylvania. It is also a natural gas producer in Beaver County in the Quaker State #1 Metropolitan Industries well (Figure 11). It is approximately equivalent to the Rhine Street Shale of New York. The second marker is approximately equivalent to the Java-Pipe Creek of New York. The rocks from the base of the zone II facies to the top of the Hamilton including the second marker, zone I facies, the first marker, and the Burket are equivalent to the Upper Olen-tangy of Ohio. The zone II facies is the third major black shale unit in Pennsylvania. This unit produced gas along Lake Erie in northwestern Pennsylvania in the old Erie, North East, and Girard fields and in a recent well, the Welch Foods, Inc. #3 (Figure 11). The zone II facies is approximately equivalent to the Dunkirk of New York and the Lower Huron of Ohio which marks the base of the Ohio shale.

Above the shales and siltstones of zone A are the sandstones of the Upper Devonian which are the traditional oil and gas reservoirs of western Pennsylvania. The first sands encountered are informally designated zone Bo. These sands are stratigraphically lower than sands which are normally prospected for in the Upper Devonian oil and gas belt of Pennsylvania and are found only in the eastern part of the study area. Zone B is the next sand zone encountered and encompasses sands from the First Warren through the Bradford Group. This sand is an important zone of oil and gas production. Zone C is a major shale-siltstone break in the section and separates zone B sands from zone D sands. Zone D includes the sands from the Venango through the Elizabeth and is also an important zone of oil and gas production. In the eastern part of the study area where zone C is no longer identifiable, sand zones D, B, and Bo merge and are grouped into one combined zone.

The defined sandstones are believed to be true lithic subdivisions. Sand zones D-B-Bo are discernable from the shale and siltstone zones C and A. The unit divisions B1-B2-B3-B4 and D1-D2-D3 within these sand zones are *interval* divisions of the zones based upon the position of known producing sands which were first named by oil and gas drillers (Figure

13). The placement of the sand refers only to the position of the sand in the area where it was first named or used.

The upper limit of the study is at the Mississippian-Devonian contact. This time boundary is difficult to pick in the subsurface, because there is no lithologic break at the boundary. The same depositional systems operated from Upper Devonian into Mississippian time. The contact is placed at the base of one of the following sands: The Berea-Cussewago-Corry-Knapp-Murrysville. Although these sands are not exactly correlative, their position marks what is called the "traditional" Mississippian-Devonian boundary. In north central Pennsylvania, a shale or siltstone is commonly present below the Mississippian-Devonian boundary and above the first sandstones. This local unit is the Riceville (Figure 14).

With the completion of the gas-show map and the stratigraphic framework, two of the objectives of the study will be completed. In the coming year, additional wells will be tied to the stratigraphic framework and data collected for mapping of the defined units. This will include distribution and thickness maps of the various facies and zones and a subsurface structural picture provided by a series of contour maps using various defined units as mapping data.

ERDA is also planning to core several wells in Pennsylvania. The exact number and location of these wells is unknown at this time. These cores will be used for physical, mineralogical and geochemical studies, and this data will be integrated with stratigraphic information in resource assessment studies. ERDA is also negotiating with Peoples Natural Gas Company to participate in stimulation of Devonian Shales in Peoples' #1 Fleck well in Mercer County (Figure 11). This well has log-indicated gas intervals in the zone I facies. Successful completion of this well would make it the third producing shale well recently completed in Pennsylvania.

The Pennsylvania Geological Survey is contracted to complete its phase of the project in November of 1978. The end product should show the extent, thickness and regional structural setting of Middle and Upper Devonian organic-rich shales above the Onondaga. This information will be combined with information from core characterization work by the U. S. Geological Survey to make an estimate of the resource potential of these shales. We believe this information together with technological developments will make these presently marginal economic resources more attractive to oil and gas operators and an important natural gas resource for Pennsylvania.

## **PART IV. SUMMARIZED RECORDS OF DEEP WELLS REPORTED IN 1976**

The information in the following tables has been compiled mainly from drillers' logs and location plats received from the Oil and Gas Division of the Bureau of Land Protection and Reclamation. Other sources are Petroleum Information Corporation (PI), geophysical logs received by the Pennsylvania Geological Survey, and personal communications with oil and gas operators. The identification numbers in Table 14 refer only to well location numbers on Figure 4 of this report. The more significant numbers are the permit numbers by which the wells are filed with the Bureau of Land Protection and Reclamation and the unique quadrangle numbers by which the Survey files the wells and locates them on 15-minute quadrangle maps.

A single asterisk appearing on a record indicates that all formation tops and total depths were picked from a geophysical log. A record without an asterisk means that the formation tops and total depths are from the drillers' log or PI. Where a double asterisk appears, the 7½-minute quadrangle name and location are given. These tables are listed alphabetically by county and by name of well.

The producing depth record still stands at 11,458 feet in the Tuscarora (Lower Silurian) sandstone, while the drilling depth record was established by the No. 1 Leonard Svetz by Amoco Production Company in Somerset County early in 1975 when the well was completed at a total depth of 21,460 feet in the Upper Cambrian.

Table 14. Summarized Record of Deep Wells Reported in 1976

MAP NUMBER	49	61	60	71	68	70	69	72	
COUNTY	Armstrong 21695	Clarion 20592	Clarion 20615	Clearfield 20582	Clearfield 20607	Clearfield 20587	Clearfield 20596	Clearfield 20609	Clinton 20188
NAME OF WELL	T. C. Crownover #1	John J. Howard #1	Leland D. Shirey #1	Green Glen #2 WH-1455	Mary K. Harris	Kewanee Oil WH-1477	James Mitchell Est #3, WH-1478	Guy Ross #1	OER Forests & Waters #1N-522
OPERATOR	Westman Petroleum, Inc.	Peoples Natural Gas #5041	Peoples Natural Gas #5078	Consol. Gas Supply Corp.	Consol. Gas Supply Corp.	Consol. Gas Supply Corp.	Consol. Gas Supply Corp.	Consol. Gas Supply Corp.	Consol. Gas Supply Corp.
TOWNSHIP	Kiskiminetas	Salem	Salem	Sandy	Brady	Penn	Bell	Huston	Leidy
QUADRANGLE	Elders Ridge D 53	Foxburg B 2	Foxburg B 3	Penfield D 283	Penfield G 285	Curwensville A 4	Curwensville A 5	Penfield B 284	Reno West B 230
LATITUDE	20,000 ft. S 40°40'	14,130 ft. S 41°15'	4,720 ft. S 41°15'	250 ft. S 41°10'	29,150 ft. S 41°05'	750 ft. S 41°00'	4,700 ft. S 41°00'	450 ft. S 41°15'	25,750 ft. S 41°30'
LONGITUDE	5,750 ft. W 79°25'	2,400 ft. W 79°35'	9,050 ft. W 79°35'	3,900 ft. W 78°40'	16,550 ft. W 78°40'	6,900 ft. W 78°40'	17,200 ft. W 78°40'	14,850 ft. W 78°35'	10,700 ft. W 77°50'
DATE COMPLETED	2-22-75	2-6-75	8-28-76	10-22-75	7-14-76	1-15-76	12-22-75	9-15-76	6-14-75
ELEVATION	1333 KB	960 KB	1524 KB	1627 KB	1872 KB	2050 KB	1844 KB	2323 KB	1573 GR
TULLY	*6734-	*4114-4126	*5134-	*6774-6882	*6702-6872	*6845-7015	*6554-6714	*5784-	*5370-5492
ONONDAGA	7249-	4271-4425	5233-	7340-7356	7430-7449	7587-7606	7254-7272	5362-	6183-6198
CHERT	7265-	Bois Blanc eq. 4425-4478	5423-	7356-7419	7450-7509	7606-7662	7272-7348	6376-	
OR SKANY	7416-7426	4478-4528	Absent	7419-7450	7509-7513	7662-7667	7348-7353	6425-	6198-6228
HELDERBERG	7426-	4528-4670	5312-	7450-7561	7513-	7667-	7353-	6449-	
KEYSER-BASS ISLAND		4670-4788	5642-					6573-	
SALINA		4788-5824	6614-					6630-	
GUELPH-LOCKPORT		5824-6143	6744-						
BLACK WATER			7130-						
CLINTON		6143-6350	7236-						
IRONDEQUOIT									
MEKINNA		6350-6560							
WHIRLPOOL									
QUINCY		6560-	7333-						
TOTAL DEPTH	7533	6666	7433	7561	7541	7781	7456	6677	6240
DEEPEST FORMATION REACHED	Helderberg	Queenston	Helderberg	Helderberg	Helderberg	Helderberg	Helderberg	Salina	Oriskany
REMARKS	556 Abandoned	127 Mcf AF 1300 psi/48 hrs.	556 Abandoned	730 Mcf Nat. 1303 psi/14 days	179 Mcf Nat. 975 psi/96 hrs. 1303 psi/14 days	4 Mcf Nat. 72 Mcf AF 1900 psi/14 hrs.	50 Mcf Nat. 949 Mcf AF 2840 psi/14 days	12 Mcf Nat. 215 Mcf AF 2850 psi/72 hrs.	39,382 Mcf 20,731 Mcf AF 3950 psi/72 hrs.



MAP NUMBER		58		51		52					
COUNTY	Permit Number	Crawford 20501	Crawford 20497	Crawford 20496	Crawford 20498	Crawford 20430	Crawford 20482	Crawford 20435	Crawford 20483	Crawford 20433	Crawford 20438
NAME OF WELL		Theodore Closky et ux #1	Maxwell Haemer #1	Richard E. Hotchkiss #1	Nick Katsilas #1	Kebert Dev., Incorporated #1	Kebert Dev., Incorporated #1	Kebert Dev., Incorporated #2	Kebert Dev., Incorporated #2	Kebert Dev., Incorporated #3	Kebert Dev., Incorporated #4
OPERATOR		Van Raalte Oil Company #C-2	Meridian Oil & Gas Enterprises	Meridian Oil & Gas Enterprises	Meridian Oil & Gas Enterprises	N-Ren Corporation	N-Ren Corporation	N-Ren Corporation	N-Ren Corporation	N-Ren Corporation	N-Ren Corporation
TOWNSHIP		Vanango	Summerhill	Summerhill	Summerhill	Greenwood	Greenwood	Greenwood	Greenwood	Greenwood	Greenwood
QUADRANGLE		Cambridge Springs H 34	Linesville C 61	Linesville C 60	Linesville C 62	Meadville G 34	Meadville G 41	Meadville G 36	Linesville I 59	Meadville G 35	Meadville G 38
LATITUDE		12,350 ft. S 41°50'	1,300 ft. S 41°45'	1,800 ft. S 41°45'	6,000 ft. S 41°45'	19,000 ft. S 41°35'	15,300 ft. S 41°35'	16,500 ft. S 41°35'	17,650 ft. S 41°35'	10,300 ft. S 41°35'	12,700 ft. S 41°35'
LONGITUDE		5,650 ft. W 80°05'	15,850 ft. W 80°15'	18,100 ft. W 80°15'	18,850 ft. W 80°15'	14,300 ft. W 80°10'	18,200 ft. W 80°10'	13,550 ft. W 80°10'	1,100 ft. W 80°15'	16,200 ft. W 80°10'	18,000 ft. W 80°10'
DATE COMPLETED		5-6-76	7-8-76	7-8-76	7-3-76	11-7-75	10-23-75	11-7-75	10-24-75	2-10-74	11-7-75
ELEVATION		1252 KB	1322 KB	1328 KB	1345 KB	1329 KB	1292 KB	1294 KB	1287 KB	1200 KB	1285 KB
TULLY		*2496-2572	2520-2560	2540-2580	2610-2650	*3183-3227	*3103-3146	*3145-3191	*3076-3118	*2972-3018	*3054-3098
ONONDAGA	LIMESTONE	2700-2858	2690-2880	2710-2900	2750-2935	3345-3538	3265-3461	3310-3508	3238-3380	3136-3333	3219-3414
	CHERT	Bois Blanc 2858-2898							Bois Blanc 3380-3446		
ORISKANY		Absent	2880-2890	2900-2910	2935-2945	3538-3547	3461-3472		Absent	3333-3340	3414-3423
HELDERBERG		2898-2922				3547-3632			Absent		
KEYSER-BASS ISLAND		2922-2964				3632-3840			3446-3540		
SALINA		2964-3594				3840-4280			3540-4250		
GUELPH-LOCKPORT		3594-3796				4280-4532			4250-4538		
BLACK WATER		3730									
CLINTON		3796-3932							4538-4652		
IRONOQUOIT		3906-3915	3830-3930	3900-3960	3900-4010	4704-4710	4612-4694	4662-4668	4598-4608	4488-4494	4563-4569
MEDINA		3932-4124	4005-4160	4020-4180	4100-4230	4757-4954	4694-4860	4716-4910	4652-4848	4540-4730	4616-4808
WHIRLPOOL		4115-4124	4150-4160	4160-4180	4220-4230	4938-4954	4844-4860	4894-4910	4832-4848	4716-4730	4795-4808
QUEENSTON		4124-	4160-	4180-	4230-	4954-	4860-	4910-	4848-	4730-	4808-
TOTAL DEPTH		4175	4205	4204	4260	4990	4920	4959	4901	4792	4838
DEEPEST FORMATION REACHED		Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston
RESULT		SSG Abandoned Cambridge Springs Extension	100 Mcf AF 20 BBL 1000 psi/24 hrs. 1000 psi/3 days Indian Springs Field	100 Mcf AF 20 BBL 1025 psi/24 hrs. 1025 psi/3 days Indian Springs Field	100 Mcf AF 20 BBL 875 psi/24 hrs. 900 psi/3 days Indian Springs Field	1,229 Mcf AF 1297 psi/48 hrs. New Field Wildcat Discovery Greenwood Field	SG AF in Oriskany. At 3970 casing collapsed, lost hole. Development Greenwood Pool	1,433 Mcf AF 1335 psi/48 hrs. Development Greenwood Field	250 Mcf AF 1280 psi/4 days Extension Greenwood Field	353 Mcf AF 1050 psi/48 hrs. Development Greenwood Field	2,078 Mcf AF 1285 psi/4 hrs. Development Greenwood Field





COUNTY	Permit Number	Erie 20401	Erie 20402	Erie 20391	Erie 366	Erie 20404	Erie 20384	Erie 20393	Erie 20374	Erie 20389	Erie 20388
NAME OF WELL	E. & P. Brooks #1	Joyce J. Carpenter #1	Joyce J. Carpenter #1	Oplacido-Private #1	Fred Edickes #1	Fairview Nurseries #1	Walter & Mary Koby #4	Edward G. Kruse #1	Francis Kuhns #1	Robert & Bessie Pettis #1	J. M. & S. Snyder #1
OPERATOR	Eratico Natural Gas Development	Eratico Natural Gas Development	Eratico Natural Gas Development	Flanigan Brothers	Meridian Exploration Corp.	Flint Oil & Gas Incorporated	Minnesota Oil & Gas Company	Flint Oil & Gas Incorporated	Milona Gas Company	Flanigan Brothers	Flanigan Brothers
TOWNSHIP	Conneaut	Conneaut	Conneaut	Springfield	North East	Fairview	Conneaut	Fairview	Elk Creek	Springfield	Springfield
QUADRANGLE	Girard 8 459	Girard 8 460	Girard 8 456	Girard 8 456	North East F 34	Erie G 125	Girard E 451	Erie G 124	Girard E 450	Girard 8 454	Girard B 453
LATITUDE	12,850 ft. S 41°57'30"	14,200 ft. S 41°57'30"	11,675 ft. S 41°57'30"	11,675 ft. S 41°57'30"	950 ft. S 42°10'	22,500 ft. S 42°05'	8,500 ft. S 41°52'30"	26,900 ft. S 42°05'	750 ft. S 41°52'30"	9,650 ft. S 41°57'30"	10,250 ft. S 40°57'30"
LONGITUDE	5,950 ft. W 80°20'00"	7,150 ft. W 80°22'30"	8,500 ft. W 80°22'30"	8,500 ft. W 80°22'30"	19,300 ft. W 79°45'	11,800 ft. W 80°10'	8,350 ft. W 80°20'	10,900 ft. W 80°10'	2,500 ft. W 80°20'30"	6,900 ft. W 80°22'30"	5,350 ft. W 80°22'30"
DATE COMPLETED	10-22-76	10-23-76	11-25-75	11-25-75	7-29-74	10-25-76	10-11-75	6-21-76	11-13-74	1-26-76	1-14-76
ELEVATION	878 KB	881 KB	887 OF	887 OF	1427 KB	935 KB	1105 KB	960 KB	1058 KB	847 OF	874 OF
TULLY	•1662-1698	•1672-1704	•1608-	•2008-2065	•2008-2065	•1502-	•2080-2107	•1647-1702	•1962-1994		
ONONAGA	1846-2098	1855-2102	•1808-	2242-	2242-	1768-	2253-2512	1867-2150	2140-	•1758-	•1804-
ORISKANY				2480-2492	2480-2492	2050-2060	2512-2520	2150-2160	2388-2403		
HELDERBERG											
KEYSER-BASS ISLAND	2098-2184	2102-2194			2492-2540			2160-2262			
SALINA	2184-2708	2194-2718						2262-2717			
GUELPH-LOCKPORT	2708-	2718-			2950-	2587-	3097-	2717-2928	3014-	2611-	2601-
CLINTON	2942-3073	2952-3083	3002-	3265-	3265-	2926-	3437-	3014-3036	3348-	2948-	2990-
MEDINA	3073-3246	3083-3256	3030-	3310-3455	3310-3455	2950-	3466-	3036-3212	3376-	2975-	3017-
WHIRLPOOL	Cabot Head 3160-3230-3246	Cabot Head 3168-3240-3256	3197-	3440-3455	3440-3455	3114-	3555-	Cabot Head 3120-3203-3212	Cabot Head 3474-3549-	Cabot Head 3062-3138-	Cabot Head 3104-3177-
QUEENSTON	3246-	3256-		3455-	3455-	3124-		3212-	3554-	3150-	3190-
TOTAL DEPTH	3295	3280	3207	3517	3517	3172	3619	3274	3604	3185	3199
DEEPEST FORMATION REACHED	Queenston	Queenston	Queenston?	Queenston	Queenston	Queenston	Cabot Head	Queenston	Queenston	Queenston	Queenston
RESULT	3,400 Mcf AF 920 psi/77 days Development Bushnell-Lexington Pool	3,100 Mcf AF 950 psi/77 days Development Bushnell-Lexington Pool	250 Mcf AF 1020 psi/72 hrs. Development Bushnell-Lexington Pool	2,000 Mcf AF 950 psi/36 hrs. Development Bull Reservoir	2,000 Mcf AF 950 psi/36 hrs. Development Bull Reservoir	NSOG Abandoned Deeper Pool Wildcat	28 Mcf AF 1100 psi/34 hrs. Lundys Lane Ext. Whirlpool and Queen. not reached drill-pipe broke.	NSOG Abandoned Deeper Pool Wildcat	Approximately 100 MCFPO Development Lundys Lane	800 Mcf AF 1000 psi/48 hrs. Development Bushnell-Lexington	90 Mcf AF 1020 psi/72 hrs. Development Bushnell-Lexington



County	Permit Number	County	20007	McLean	33511	Mercer	20116	11067	21067	Westmoreland	20806
NAME OF WELL	Mary Louise Hess #1	Erie Lackawanna RR #1	Erie Lackawanna RR #1	Say #1	James E. Fleck #1	James E. Fleck #1	Carroll Neal #1	H. & M. Piccoli, et ux #1			
OPERATOR	John H. Ware, 3rd	Fairman Drilling Company	Fairman Drilling Company	Minard Run Oil Company	Peoples Natural Gas Company	Peoples Natural Gas Company	Consol. Gas Supply Corp.	Snee & Eberly & Peoples Natural			
TOWNSHIP	Mifflin	Lafayette	Lafayette	Lafayette	Sandy Creek	Sandy Creek	Chatham	S. Huntingdon			
QUADRANGLE	Trout Run G 4	Bradford H 12	Bradford H 12	Bradford E 13	Stoneboro A 17	Stoneboro A 17	Elkland E 43	Connellsville B 7			
LATITUDE	16,000 ft. S 41°20'	13,275 ft. S 41°50'	13,275 ft. S 41°50'	17,950 ft. S 41°55'	13,900 ft. S 41°30'	13,900 ft. S 41°30'	12,640 ft. S 41°55'	29,850 ft. S 40°15'			
LONGITUDE	10,650 ft. W 77°10'	10,450 ft. W 78°35'	10,450 ft. W 78°35'	8,450 ft. W 78°35'	19,650 ft. W 80°10'	19,650 ft. W 80°10'	13,075 ft. W 77°20'	21,300 ft. W 79°35'			
DATE COMPLETED	11-2-76	3-9-76	3-9-76	5-5-76	3-12-76	3-12-76	9-9-76	3-22-76			
ELEVATION	738 K8	2100 K8	2100 K8	2244 K8	1339 K8	1339 K8	1755 K8	1220 K8			
TULLY	*4844-5000	*4845-4928 Broken	*4845-4928 Broken	*4733-4805	*3295-	*3295-	*3788-	*6757-6765			
ONONDAGA	6208-6271	5391-5452	5391-5452	5170-5217	5170-5217	5170-5217	4644-	7215-7230			
CHERT		5465-5604	5465-5604	5217-5230	5217-5230	5217-5230		7230-			
ORISKANY	6271-6299	Absent	Absent	Absent	3635-	3635-	4655-	7411-			
HELDERBERG	6299-6325	5604-5645	5604-5645	5230-5265							
KEYSER-BASS ISLAND SALINA				5265-5342	3754-	3754-					
GUELPH-LOCKPORT BLACK WATER				5342-6205	4507-	4507-					
CLINTON				6205-6408							
IRONDEQUOIT				6408-6600							
MEDINA				6520-6525	4896-	4896-					
WHIRLPOOL				6600-6760	4968-	4968-					
QUEENSTON				6690-6760	5001-	5001-					
				6760-	5129-	5129-					
TOTAL DEPTH	6325	5645	5645	10,304	9196	9196	4660	7478			
DEEPEST FORMATION REACHED	Holderberg	Holderberg	Holderberg	Cambrion	Precambrian	Precambrian	Oriskany	Oriskany			
RESULT	250 Mcf Nat. 1,100 Mcf AP 3800 psi/4 days New Field	SSG Abandoned Deeper Pool Wildcat Bradford Field	SSG Abandoned Deeper Pool Wildcat Bradford Field	Trenton 9125-9200 9830-9900 Minard Run Pool Extension	Reedsville 5920-6000 Trenton 7105-7200 Beekmantown 7707-7800 Galesburg 7945-8000 Granite 9136-9200 231 Mcf AP, Disc. Sheakleyville	Reedsville 5920-6000 Trenton 7105-7200 Beekmantown 7707-7800 Galesburg 7945-8000 Granite 9136-9200 231 Mcf AP, Disc. Sheakleyville	SSG Abandoned New Field Wildcat	300 Mcf Nat. 3,000 Mcf AP 3625 psi/12 days Development Batley Pool			

